NASA Technical Memorandum 89604

Reference Mission Operational Analysis Document (RMOAD) for the Life Sciences Research Facilities

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FOREWORD

The Space Station will be constructed during the next decade as an orbiting, low-gravity, permanently manned facility. This facility will provide a multitude of research opportunities for many different users. The pressurized research laboratory will allow Life Scientists to study the effects of long term exposure to microgravity on humans, animals, and plants. The results of these studies will increase our understanding of this foreign environment on basic life processes and assure the safety of man's long term presence in space.

This "Reference Mission Operational Analysis Document" establishes initial operational requirements for the use of the Life Sciences Research Facility (LSRF) during its construction. This report was prepared for National Aeronautics and Space Administration Headquarters and contains integrated Johnson Space Center and Ames Research Center operational inputs for the LSRF. Investigations identified in the "Life Science Space Station Planning Document: A Reference Payload for the Life Sciences Research Facility" were used as a baseline reference for the generation of data presented in this report.

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ACRONYMS

AC	Alternating Current
AI	Artificial Intelligence
ARC	Ames Research Center
BIA	Bus Interface Adapter
BmRP	Biomedical Research Project
BRP	Biological Research Project
BSHF	Biological Specimen Holding Facility
CCSDS	Consultive Committee for Space Data Systems
DC	Direct Current
ECS	Environmental Control System
EPDS	Electrical Power Distribution System
FOC	Full Operating Capability
HRF	Human Research Facility
IOC	Initial Operating Capability
ISO	International Standards Organization
JSC	Johnson Space Center
Kbps	Kilobits Per Second
LAN	Local Area Network
LSRF	Life Sciences Research Facility
Mbps	Megabits Per Second
MDE	Mission Dependent Equipment
NIU	Network Interface Unit

PI	Principal Investigator
PMC	Permanently Manned Capability
POCC	Payload Operations Control Center
RMOAD	Reference Mission Operational Analysis Document
SDP	Standard Data Processor
SSIS	Space Station Information System
TBD	To Be Determined
UTC	Universal Time Code
VCR	Video Cassette Recorder

1.0 INTRODUCTION

The goal of the Life Sciences Program is to optimize early science return during the construction phase of the Space Station Life Sciences Research Facility (LSRF). Reference Mission Operational Analysis Document (RMOAD) presents the operational requirements for a candidate set of investigations which could be performed during the construction of the LSRF.

This report is the beginning of the definition phase of the LSRF and defines an operational approach for the utilization of the LSRF using reference payloads which generically define onboard procedures, resources and logistics. Reference payloads incorporated into this report were based on the "Redbook" which is "NASA Technical Memorandum #89188, Life Sciences Space Station Planning Document: A Reference Payload for the Life Sciences Research Facility".

The "Redbook" defines two sets of experiments: Mission A and Mission B. The experiments listed in the "Redbook" were extracted from JSC 20799, "Life Sciences Research Laboratory Human Research Facility (HRF)", commonly known as the "Bluebook" and from the "Life Sciences Objectives and Representative Experiments, Biological Research Project" commonly known as the "Greenbook". These reference documents describe approximately 90 human and 170 plant and animal hypothetical experiments.

1.1 SCOPE

RMOAD encompasses only the Life Science pressurized module payloads described in Mission SAAX 307, Space Station Mission Requirements Data Base (MRDB).

2.0 ASSUMPTIONS AND GUIDELINES

The following general assumptions and guidelines were used as the basis for this report:

2.1 MISSION TIMEFRAME

The RMOAD mission scenario encompasses a two year period within the time frame 1994 (Permanently Manned Capability (PMC)) through 1998-2005 (Initial Operating Capability (IOC)). Full Operating Capability (FOC) of the Space Station will be from the year 2005 to 2025.

2.2 INVESTIGATIONS

The "Redbook" represents generic science objectives and hardware requirements which can be accommodated with assumed resources. Descriptions of the investigations used for this analysis are located in Appendix A.

The Biomedical Research Project (BmRP) refers to investigations using crew-members as subjects and the Biological Research Projects (BRP) refers to investigations using non-human subjects such as rodents, primates or plants.

Experiments have been designed for a 180 day duty cycle. Materials management and logistics are based on 90 day accounting cycles to correspond to a Shuttle launch every 90 days.

Sharing experiment samples or specimen parameters has not been addressed in this report.

This analysis does not include ground operations, integration and testing support necessary for Life Sciences experiments.

This report is partially based on a reference Space Station configuration and operational policies which are subject to change. Current Space Station plans lack the detail necessary for a detailed and comprehensive analysis.

RMOAD will evolve as significant changes to Space Station configuration and operational policy occur and when detailed information is made available to the Life Sciences community.

2.3 RESOURCE DATA

Experiment specific, detailed engineering data is contained in this report and is presented for reference only. The data presented represents extrapolated data from the references used. Data describing operational hardware were based on existing hardware and estimated data for proposed equipment to be designed and fabricated.

2.4 LSRF CONSTRUCTION AND SUPPORTING SHUTTLE MISSIONS

The LSRF construction phase will be two (2) years in duration. There will be two categories of supporting Shuttle missions during this two year time frame:

(1) Four (4) dedicated Life Sciences Missions during the LSRF construction phase with the initial launch at PMC with follow-on missions at six (6) month intervals.

(2) Routine missions will be launched every 90 days which will provide logistics support for operational Life Sciences payloads.

Figure 2.4.1 summarizes the LSRF construction sequence and logistics missions.

2.5 LSRF CONSTRAINTS

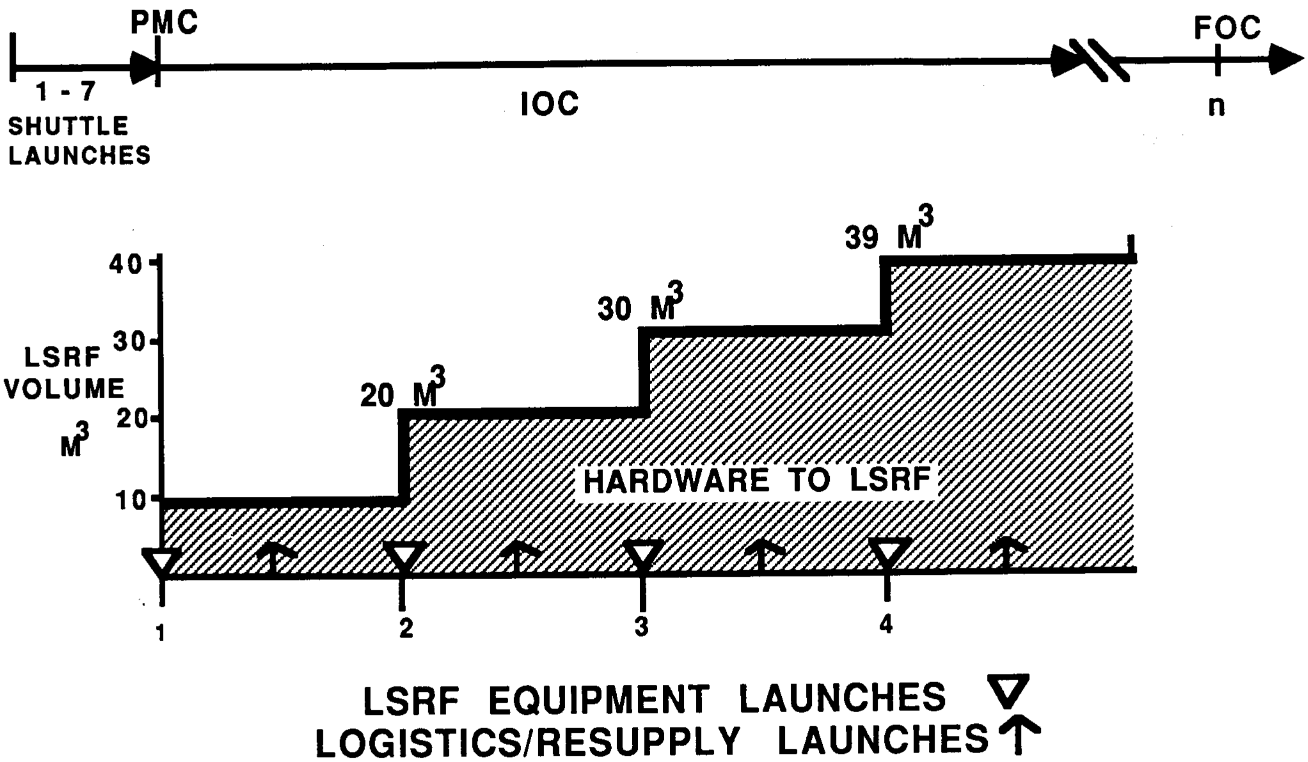
Life Sciences equipment will be consolidated in a dedicated pressurized Life Sciences Module and, per the MRDB, will have provisions for approximately:

(1) 39 cubic meters of rack volume
(2) 8500 kilograms of mass
(3) 14 kilowatts of total average power
(4) 66 hours per week of crew time per 180 day duty cycle

As a result of this analysis the constraints were changed to the following:

(1) 39 cubic meters of rack volume
(2) 13700 kilograms of mass
(3) 7.4 kilowatts of total average power
(4) 72 hours per week of crew time per 180 day duty cycle

Estimates for rack volume, mass, power and crew time are presented in the Appendices.



NOTE: MAJOR LAUNCHES MAY BE AUGUMENTED WITH INTERMEDIATE "LAUNCHES OF OPPORTUNITY"

FIGURE 2.4.1 LSRF CONSTRUCTION SEQUENCE

2.5.1 <u>LSRF Rack Layout Constraint</u>

Since the final rack configuration has not been determined, a "rack equivalent" of one cubic meter was used for the rack layout. Rack allocations were previously distributed to the BRP and BmRP on a per cubic meter basis. The respective project allocations are comprised of rack mounted hardware and rack stowage in terms of cubic meter volume. The rack layout is composed of rackmounted hardware configured according to the height dimension with the remaining space designated as stowage. Rack mounted hardware configured by height dimension occupies more rack space than the cubic meter volume would indicate. Therefore, rack layouts only serve as a pictorial representation of how the hardware could be configured for each LSRF construction phase. Actual hardware and stowage volume must be obtained from the equipment matrix. Reference the rack layout diagrams for each phase in Appendices C,D,E, and F.

3.0 OPERATIONS SCENARIO

The following hypothetical LSRF mission scenario presents the logistics and resources necessary to support a proposed LSRF construction sequence. Supporting data is presented in Appendices A,B,C,D,E,F.

3.1 LSRF CONSTRUCTION SEQUENCE

The four construction phases of the LSRF are supported by four dedicated Life Sciences Shuttle missions. Each construction phase described below integrates an increasing inventory of equipment which incrementally increases research capability and science return during the two year construction of the LSRF.

3.1.1 Phase One

The assembly of BmRP and BRP equipment will be sequenced to maximize science return from the limited hardware and crew time available during the overall LSRF construction phases. See Figures 3.1.1 and 3.1.2. A rodent habitat will be operated without animals for operational checkout, troubleshooting small problems, and bioisolation verification during the first 90 days ofAfter the holding facilities checkout is completed, rodents will be transported to the LSRF for the second 90 days of phase one. A cage cleaner and multipurpose work bench will also be tested. Twenty-one BmRP experiments were selected by JSC SD12 and five BRP investigation were selected by ARC to be conducted during this phase. These experiments were considered the primary candidates for early accomplishment during this phase due to crew time constraints. Only portions of some elected experiments are considered appropriate for this phase.

MISSION SEQUENCE	PHASE 1	PHASE 2	PHASE 3	PHASE 4
SUBJECTS	6 CREW	6 CREW	6 CREW	6 CREW
MISSION EMPHASIS	CONDUCT THOSE EXPERIMENTS WHICH OFFER MAXIMUM SCIENCE RETURN FOR MINIMUM INVESTMENT OF CREW TIME. SPECIAL EMPHASIS ON EVA, RADIATION ANALYSES, AND CALCIUM DYNAMICS. *INCLUDES THE 1.8 M CENTRIFUGE.	CONDUCT THOSE EXPERIMENTS WHICH OFFER MAXIMUM SCIENCE RETURN FOR MODERATE INVESTMENT OF CREW TIME WHEN ADDED TO THE FIRST SET. SPECIAL EMPHASIS ON EXERCISE, PHYSIO-LOGICAL RESPONSE, AND HEMODYNAMICS.	DELIVER EQUIPMENT THAT WILL BE REQUIRED WHEN THE LSRF IS COMPLETE. ADD CAPABILITY TO COLLECT AND ANALYZE BLOOD SAMPLES.	COMPLETE LSRF OUTFITTING. CONCLUDE CAPABILITY TO CONDUCT ALL BIOMEDICAL STUDIES.

FIGURE 3.1.1 BmRP MISSION EMPHASIS

MISSION SEQUENCE	PHASE 1	PHASE 2	PHASE 3	PHASE 4
SPECIMEN LOADING	12 RATS @ 0-G 24 RATS @ 1-G (L-1 RESUPPLY)	24 RATS @ 0-G 24 RATS @ 1-G	24 RATS @ 0-G 24 RATS @ 1 -G 1 RHESUS (POSS.) 30 PLANTS (POSS.)	24 RATS @ 0-G 24 RATS @ 1-G 2 RHESUS 60 PLANTS
MISSION EMPHASIS	1. HABITAT ASSY 2. HABITAT TEST 3. OP'S VERIFICATION FOR HABITATS, WORK BENCH, CAGE CLEANER. 4. SECOND 90 DAYS ANIMAL MONITORING.	1. SYSTEMS & BIOLOGICAL DATA DOWNLINK 2. INSTALL SUPPORT HARDWARE. 3. INSTALL & SUPPORT RAT SPECIMENS 4. CONDUCT LIMITED SPECIMEN TISSUE ACQUISITION 5. SCIENCE RETURN FOR BONE/ CALCIUM MUSCLE, RADIOBIOLOGY.	1. INSTALL RHESUS & PLANT HABITATS 2. TEST RHESUS & PLANT HABITATS 3. LIMITED SCIENCE RETURN ON RHESUS & PLANTS DUE TO LIMITED CREW TIME. 4.. INSTALL ADD'L INSTRUMENTS FOR RAT EXPERIMENTS 5. SCIENCE RETURN FOR BONE/ CALCIUM, MUSCLE, RADIOBIOLOGY, NEURO, HEMOTOLOGY, METAB., REG., & IMMUN..	1. ADD RHESUS & PLANT HABITATSS & BEGIN FULL SCALE OPERATION 2. SCIENCE RETURN FOR ALL PREVIOUS' DISCIPLINES PLUS CARDIOVASCULAR, AND PLANT PHYS. 3. FUTURE LAUNCHES WOULD BE FOR CHANGING MODULAR HABITATS, DELIVERING SUPPLIES & RETURNING SAMPLES & TRASH.

FIGURE 3.1.2 BRP MISSION EMPHASIS

3.1.2 Phase Two

For Phase two 72 hrs/wk crew time will be available but, as in phase one, assembly and checkout of the equipment in the LSRF will remain the primary activity. For the BRP, it is estimated that two habitat holding facilities with the full complement of rodents and limited physiologic data acquisition can be supported. The majority of the scientific analyses will be accomplished postflight. The BmRP experiments selected for phase two include ongoing and additional experiments which will be supported by new equipment and expendables delivered during this phase. Sixteen BmRP and ten BRP experiments are identified which can be accommodated during phase two.

3.1.3 Phase Three

Assembly and checkout of the LSRF equipment remains top priority. Sufficient crew time and support equipment will be available to support rodent, rhesus and plant specimens, in addition to providing specimen analysis on board. Available crew time will limit inflight research on rhesus and plant specimens, but extensive sacrifice and fixation of rodents will be possible. This phase will be the first opportunity to deliver equipment necessary for full laboratory operation after phase four. This phase will contain a mixture of the equipment required for blood and urine analysis and the equipment to be used after phase four delivery. Seventeen BmRP investigations and nine BRP investigation have been identified for this phase.

3.1.4 Phase Four

The redundant balance of required equipment will be delivered and integrated into the LSRF to allow for full scale operation. The remainder of the BRP and BmRP studies will be activated. All inflight specimen manipulations, sacrifice, fixation, and analysis will be possible. Twenty-one BmRP investigations and eleven BRP investigations have been identified for this phase.

3.2 LOGISTICS

Complex logistical support will be required to implement the construction and maintenance of the LSRF. The phased construction scenario provides for four missions to transport equipment to the LSRF at 180 day intervals. The sequence of equipment being transported was selected to permit investigations to be initiated as soon as supporting equipment is integrated and checked. The second, third and fourth missions will contain equipment to support a 12% per year (3% per 90 day cycle) equipment changeout requirement and will also transport the next 10 cubic meters of available equipment to be integrated. A resupply mission will carry items required to resupply the investigations in progress as well as replacement equipment, or changeout equipment, at 90 day intervals. The resupply return mission will transport samples, trash, failed and replaced equipment from the previous 90 days to earth.

The logistical data for each phase is incorporated into matrices in Appendices C,D,E, and F which support each phase respectively. Logistical data was extrapolated using the following guidelines:

(1) Equipment will be packaged in easy to unstow containers which add 20% to the equipment volume. Containers are considered trash after the equipment is removed.

(2) Rack mounted equipment will be removed from the containers and directly integrated into the LSRF racks.

(3) Stowed equipment will be in drawers within the containers. These drawers will be directly inserted into the LSRF racks after removal from the containers.

(4) There will be a minimium of two Logistics Modules transported by the Shuttle in support of the LSRF. The first module will be unloaded and remain with the Space Station where samples, trash and returned equipment from the previous 90 days will be loaded and returned to earth after the second logistics module arrives.

(5) 10% of the equipment may fail each 90 days. Equipment will be shipped for replacement of unrepaired equipment in the LSRF. Failed equipment will return in the logistics module for repair on earth.

3.3 LSRF RESOURCES

Operational resources required to support Life Sciences investigations in the Space Station are:

(1) Thermal and Power
(2) Data/Video/Voice Communications
(3) Crew

Each area is addressed in this section in more detail. Guidelines used for creation of resource data are as follows:

(1) 10 cubic meters of LSRF hardware will be available for phase one. The second, third and fourth phases will transport approximately 10 cubic meters each for a total LSRF hardware volume of 39 cubic meters. Detailed schedules, protocols and experiment descriptions are located in Appendix A.

(2) Experiments are timelined on a weekly basis, therefore the thermal and power requirements are derived from a weekly average. This power profile is not a function of experiment and equipment timeline and does not reflect actual peak load requirements.

(3) Resources discussed include only those for experiment hardware. The requirements for subsystem equipment and mission dependent equipment (MDE) have not been included.

3.3.1 Thermal and Power Requirements

The thermal and power analyses for each phase are presented in Appendices C,D,E and F. The following guidelines were used:

(1) Average thermal and power requirements were estimated using the weekly experiment schedule and the equipment usage associated with those investigations. To compensate for warm-up and standby times, all switchable equipment usage times were increased by 20%. Thermal load was estimated by adding the metabolic heat load to total power requirements.

(2) Equipment which is operated continuously accounts for a large percentage of the power usage and thermal load. This equipment includes the urine collection system, freezers, refrigerators, incubators, dynamic environment measurement system, and the plant and animal holding facilities.

(3) Certain hardware systems associated with the operation of the facility such as the data system, trash compactor, video system and the hand wash facility are not directly associated with experiment protocol, but are necessary for the maintenance of the facility and in many cases assist the experiment performance. These systems will be used for short periods during each day.

(4) The average thermal and power requirements estimates for the BRP complement of the LSRF are added to the average thermal and power requirements for the BmRP.

(5) The average metabolic heat load dissipated in the LSRF is 900 watts, which includes the animal and crew metabolic loads.

(6) All equipment power values are DC equivalents. DC to AC and AC to DC conversion losses were not considered.

(7) Heat leak through multi-layer insulation (MLI) and structural penetrations is negligible.

(8) Thermal load resulting from air exchange with other Space Station modules is negligible.

(9) Line losses were not considered.

(10) The experiment data system will be used 2.4 hours per day.

(11) The hand wash facility will be used 45 minutes per day.

(12) The trash compactor will be used 45 minutes per day.

(13) The video system will be used for 1.5 hours per day.

(14) Only total thermal requirements were estimated. Loads on various heat absorber loops were not identified due to lack of data.

(15) AC and DC power requirements were not identified separately.

3.3.1.1 LSRF Thermal Subsystem

LSRF thermal requirements must be accommodated by the module/station Environmental Control and Life Support System (ECLSS). The LSRF ECLSS should provide thermal control for subsystem, mission dependent and experiment equipment and provide atmosphere/pressure control. The atmosphere/pressure control includes module oxygen, nitrogen and carbon dioxide partial pressures and experiment vacuum venting. The ECLSS should incorporate thermal control elements associated with heat collection transfer, storage and rejection.

The primary functions of the LSRF ECLSS should be:

(1) Atmosphere/pressure control

(2) Vacuum venting

(3) Atmosphere contamination control

(4) Fire detection and suppression

(5) Active thermal control of subsystem and experiment equipment, to include heat collection, transport, storage and rejection.

(6) Passive thermal control through multi-layer insulation.

The LSRF ECLSS must have the following capabilities and heat absorber loops:

(1) CABIN AIR LOOP. This loop will maintain a habitable environment for the crew. This loop will also accomplish limited cooling for equipment that is utilized in the habitable area. The air exchange with other modules is also provided. The cabin air loop will also provide smoke detection and fire suppression in the habitable area.

(2) AVIONICS AIR LOOP. This loop is the primary heat absorber loop for air cooled equipment. Air cooling can generally be classified in two modes (a) suction cooling (b) surface cooling. Air cooling of rack mounted equipment

will be generally accomplished by the avionics air cooling loop. This loop also provides smoke detection and fire suppression in the racks. Flow and heat rejection capabilities for this loop are based on the total LSRF experiment and subsystem requirements.

(3) WATER COOLING LOOP. The loop will support all the water cooled equipment. Water cooling can be accomplished using cold plates or heat exchangers. Animal holding facilities and the multi-purpose work bench are candidates for water cooling. Equipment that generates high thermal loads are also candidates for water cooling.

(4) EXPERIMENT VENT SYSTEM. This system will be used to dump breathing gases overboard and for reactivating the Gas Analyzer Mass Spectrometer (GAMS) in the event of vacuum loss.

3.3.1.2 LSRF Power Subsystem

The LSRF Electrical Power Distribution System (EPDS) will distribute AC and DC electrical power to experiment equipment and LSRF subsystems. The EPDS will receive power from the Space Station Electrical Distribution Network. This network will provide the necessary circuit protection for the LSRF EPDS.

The LSRF and the experiment equipment requirements for the EPDS can be summarized as follows:

(1) Stabilized AC and DC power.

(2) 28 V DC for Life Sciences Laboratory Equipment (LSLE). No other DC voltage requirements have been identified at this time.

(3) AC voltage requirements were not available for this report.

In general, to maintain the life support capabilities of the animal holding facilities and to preserve the biological samples and specimens, a large percentage of the experiment hardware will require continuous power with supporting cooling, smoke detection and fire suppression capabilities. In addition, precise environmental control and monitoring will be required to achieve reliable scientific data due to the enviromental sensitivity of biological systems.

3.3.2 LSRF Command and Data Management System Requirements

The LSRF Command and Data Management System (CDMS) requirements are presented in three sections:

(1) LSRF Data System

(2) LSRF Video System

(3) LSRF Voice Communications System

In developing the data/video/voice communications requirements the following assumptions were made:

(1) The computers that will be incorporated in the Space Station and LSRF will take advantage of the latest technological advances.

(2) LSRF equipment will be designed to enable the most efficient use of the Space Station communications system.

(3) Only LSRF experiment hardware and ground support requirements were considered.

(4) LSRF experiment data outputs will be similar to Spacelab experiment data outputs.

(5) A data playback unit will be designed to allow playback of tapes recorded in 24 hour monitoring sessions.

3.3.2.1 LSRF Data System Requirements

The basic requirements for the LSRF Data System are as follows:

(1) The system should be capable of transmitting digital data from the LSRF to ground support facilities.

(2) Date rate requirements range from single discrete inputs to a composite data rate of 400 kilobits per second.

(3) The LSRF inflight digitizing system will output single channel data rates of 14 megabits per second which will be recorded and downlinked later at a slower rate of 256 kilobits per second to support high resolution digitized video.

(4) An interface mechanism is required to convert discrete, analog and serial measurements to the Space Station Packetized Data Format.

(5) Onboard data processing is required to provide caution and warnings, limit sensing on selected parameters, and quick look capability for engineering and experiment status parameters.

(6) To prevent data losses, onboard data buffering at data rates up to 400 kilobits per second is required. This buffering should preclude loss of data due to LSRF to ground support facility communications link failure, not to include the failure of the user's onboard or ground support facilities.

(7) Command interfaces between the LSRF and the ground support facilities are required. The command traffic is necessary to enable the uplink of data base information pertaining to experiment protocols, CAD drawings, and malfunction procedures. The command interfaces will also be used to control many of the environmental, care, and monitoring functions associated with the animal experiments. In addition, the command interface will be used for video equipment.

(8) Universal Time Code (UTC) timing is required for activity coordination and data correlation. In addition, this timing will be used by dedicated experiment processors and be superimposed on video signals when required.

3.3.2.1.1 LSRF Data System Design and Operation

The LSRF CDMS will be compatible with the Space Station Information System (SSIS), which is a Wide Area Network (WAN), capable of supporting all experiment sessions in the LSRF. The SSIS will make use of Local Area Networks (LAN) which support individual modules and interface through a gateway with a Space Station Global LAN. Once LSRF data is on the Global LAN it can be accessed by other global elements or by ground personnel through the SSIS communications and tracking function. The SSIS communications and tracking function interfaces through the Tracking and Data Relay Satellite System (TDRSS) to the

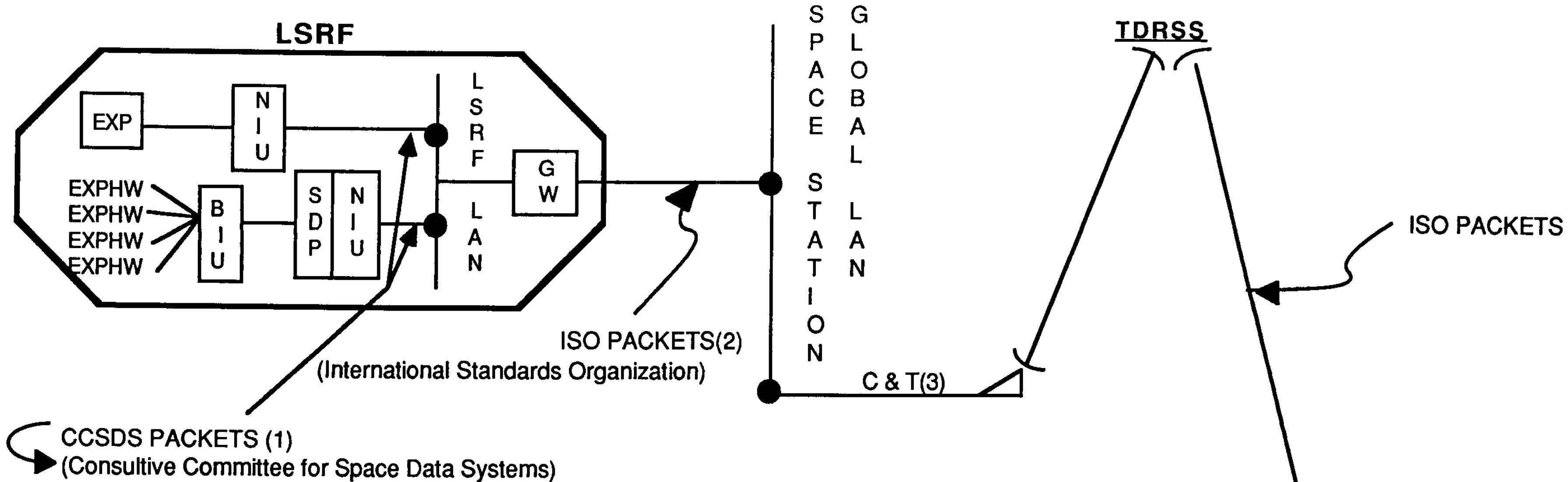
Space Station Ground Communications Center where data will be distributed to the user's facility, or a multi-user Payload Operations Control Center (POCC). Figure 3.3.2.1 represents the overall data flow and provides additional information on the LSRF and SSIS.

Onboard data processing will be facilitated by user generated software and computing equipment and will be made available to the crew through Space Station provided data processors.

The LSRF CDMS will be a module LAN capable of digital data transfer in the Space Station LAN data format. The system will make provisions for the conversion of discrete, analog, and low rate (less than 1 kilobit per second) serial data into a LAN compatible format. Experiments which generate data rates greater than 1 kilobit per second will require a Space Station LAN format. Single experiment data will be described using Consultive Committee for Space Data Systems (CCSDS) packets which contain data source and destination.

LSRF low data rate hardware (below 1 kilobit per second) will interface to the LSRF LAN through Bus Interface Adapters (BIA) connected to a Standard Data Processor (SDP). The SDP then interfaces to the LSRF LAN through a Network Interface Unit (NIU). The high data rate hardware, such as playback recorders, inflight digitizing system, LSLE microcomputers and generic Space Station Crew Workstations, will interface with the LSRF LAN through individual NIUs. The LSRF LAN then interfaces to the Space Station Global LAN through a gateway. Data to and from the LSRF must go through this gateway to minimize global LAN traffic. Data from the LSRF LAN is structured into International Standards Organization (ISO) packets to distinguish one payload from another. See Figure 3.3.2.2 for a detailed presentation of the LSRF CDMS.

The failure of any LSRF Data System element, i.e. the LAN elements, experiment equipment, dedicated experiment processors, or standard data processors, will not cause the failure of the entire LAN system. Provisions must be made onboard for the repair or replacement of communication system constituents. Alternate communications paths must be available for data transfer if an existing path fails and should be made apparent to the crew and ground support personnel so that corrective action can be taken.



(1) CCSDS PACKETS CONTAIN A CCSDS HEADER WHICH DESCRIBES THE SOURCE AND DESTINATION OF THE PACKETIZED DATA. THESE HEADERS ARE USED TO DESCRIBE DATA FOR A SINGLE EXPERIMENT.

(2) ISO PACKETS CONTAIN HEADERS WHICH ARE USED TO MINIMIZE UNNECESSARY TRAFFIC ON A PAYLOAD LAN BY DISTINGUISHING ONE PAYLOAD FROM ANOTHER.

(3) COMMUNICATIONS AND TRACKING FUNCTION OF THE SPACE STATION

(4) THE GROUND COMMUNICATIONS CENTER IS THE DISTRIBUTION AND PROCESSING CENTER FOR THE SPACE STATION PROGRAM.

(5) THE PAYLOAD OPERATIONS CONTROL CENTER (POCC) IS A USER OF THE SPACE STATION PROGRAM. THE POCC ALSO SUPPORTS ITS OWN USERS.

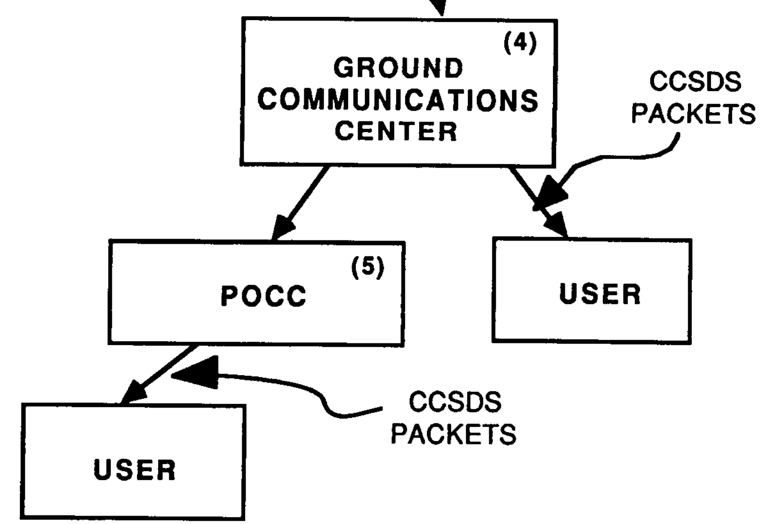
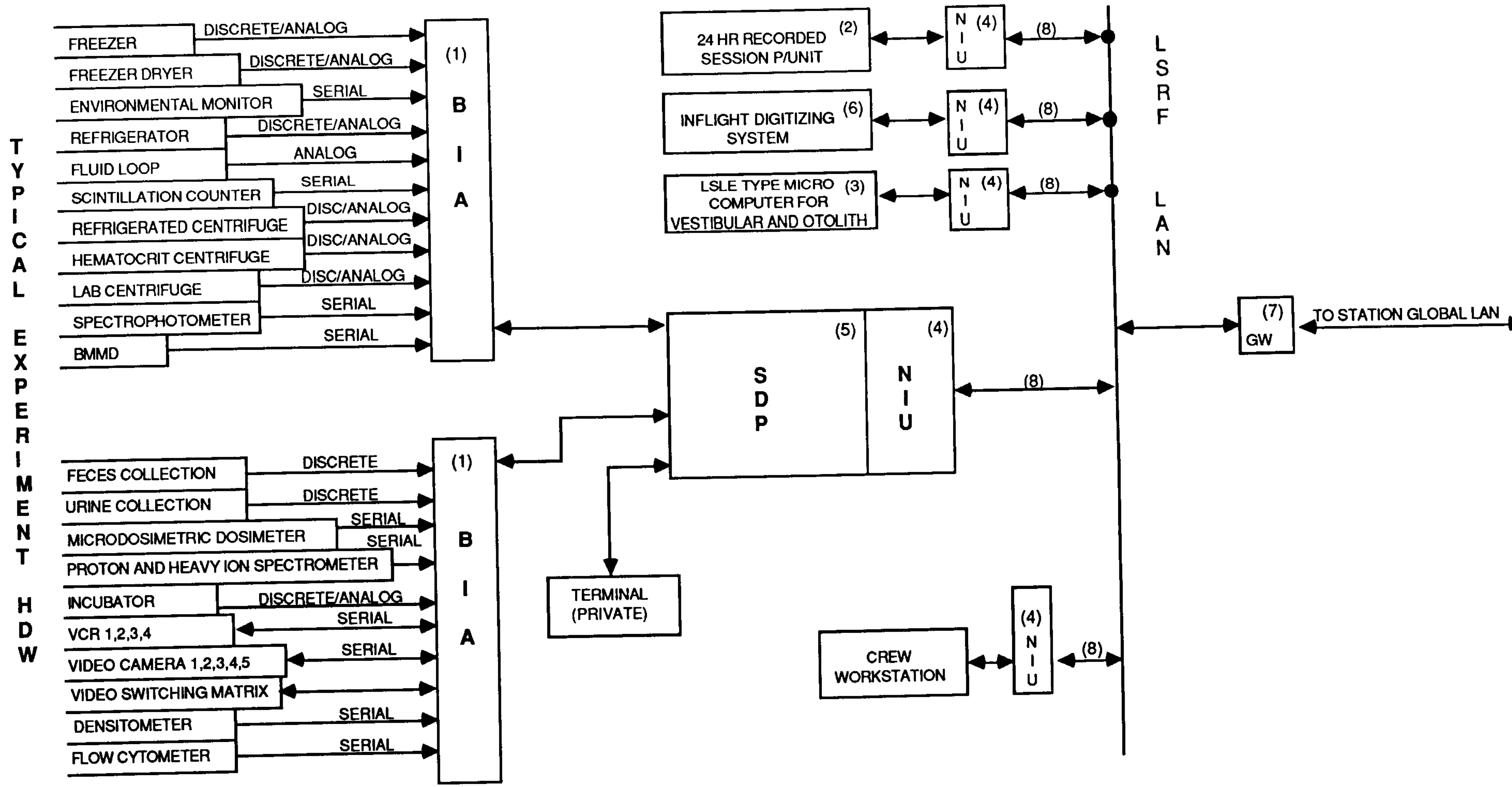


FIGURE 3.3.2.1 OVERALL DATA FLOW



(1) THE BUS INTERFACE ADAPTER IS MUCH LIKE THE CURRENT SPACELAB RAU.
(2) THE PLAYBACK UNIT IS FOR GONIMETER, DOPPLER, ACCELEROMETER, AND FORCE MEASUREMENT DEVICE TAPE PLAYBACKS. IT WILL HAVE A NETWORK COMPATIBLE PROTOCOL.
(3) THE LSLE MICRO COMPUTER WILL CONTROL AND MONITOR VESTIBULAR EXPERIMENTS. IT WILL HAVE A NETWORK COMPATIBLE PROTOCOL.
(4) THE NETWORK INTERFACE UNIT IS THE HARDWARE INTERFACE UNIT TO THE LAN.
(5) THE STANDARD DATA PROCESSOR IS A MULTIFUNCTION COMPUTER CAPABLE OF FORMATTING INPUTS FROM SENSORS. IT PERFORMS DATA PROCESSING FOR CREW MONITORING OF SYSTEMS AND SUBSYSTEMS.
(6) THE INFLIGHT DIGITIZING SYSTEM WILL HAVE A 13 MBPS OUTPUT. THIS OUTPUT MUST BE FORMATTED INTO A NETWORK COMPATIBLE PROTOCOL.
(7) THE GATEWAY INTERFACES THE LSRF LANS TO THE STATION GLOBAL LAN. ALL DATA TO AND FROM THE LSRF, THE SPACE STATION ELEMENTS AND GROUND ELEMENTS MUST GO THRU THE GATEWAY. THE GLOBAL LAN WILL BUFFER AND STORE DATA DURING PERIODS OF BROKEN COMMUNICATION.
(8) PACKETIZED TELEMETRY WILL TRAVEL VIA THE LAN. THE UTC AND OTHER TIME SIGNALS WILL BE DOWNLINKED FROM SPACE STATION ON THE LAN.

FIGURE 3.3.2.2 LSRF CDMS

The Space Station network protocols must make provisions for the proprietary nature of certain life sciences data. This will be facilitated by the space station systems and will allow sensitive data to be distributed without compromise.

The LSRF will make available to the users a method by which digital cassette tapes recorded during extended crew activity monitoring sessions, (i.e. strap on equipment sessions), can be downlinked. This method is necessary to minimize stowage requirements for these experiments. The downlink of this data will be at an accelerated rate. This will minimize the time necessary to get this data to the ground and the crewtime required for playback control.

3.3.2.1.2 LSRF Ground Support System Design and Operation

Ground data processing will be used almost exclusively in support of the LSRF experiments. Onboard processing will be used to support the crew and minimize data downlink.

The LSRF requires the use of Space Station ground support facilities for two levels of data distrubution, and for limited data storage in case of distribution failure.

The first level of distribution is to the end user. The communications services required for a user's facility and any additional data processing will be the responsibility of the user. The Space Station data handling facility will ensure the integrity and privacy of a user's data except for the user's communications circuits. Packet header protocols assigned by Space Station will ensure that user's data is not compromised due to routing failures. The distribution system will have the capability of routing shared data when this requirement exists.

The second level of distribution will be to a multi-user facility, such as a Payload Operations Control Center (POCC). Users will have the same privileges and responsibilities as mentioned in level one. Facility management will ensure proper data distribution and privacy of data when required. Users will be required to identify the necessary data processing and products to support their investigations.

3.3.2.2 LSRF Video System Requirements

(1) The LSRF video system requires three video channel interfaces, with channel recording and storage capabilities, to ensure simultaneous support of experiments.

(2) The video system requires privacy of sensitive video.

3.3.2.2.1 LSRF Video System Design and Operation

Analog experiment video will be digitized by the Space Station Video System for TDRSS downlink, then converted back to analog in the Space Station Data Handling Facility for distribution to the user. Sensitive video will not be available for general distribution. Video data should have integrated UTC timing codes and incorporate synchronized voice for experiment support. In addition, the LSRF video system should have the capability of simultaneous downlink of real-time and playback video, and simultaneous distribution to the user. The system should have the additional capability of split screen imaging and allow for special effects displays.

The LSRF should have as minimum standard equipment, 5 video cameras, 2 video monitors, 4 video cassette recorders and a video switching matrix. Two of the video cameras should be remote control fix mount type. The remote control should have the capability for pointing, focus, zoom, and black/white or color control. The remote control cameras must have a LAN compatible controlling mechanism to ensure camera control by the onboard crew or ground support personnel. A third camera should be remote controllable and removable for hand held operations. Cameras four and five will be used to monitor animals in the holding facilities and should be remote controllable with the capability of being relocated on various mounts within the facilities.

The LSRF video monitors should be high resolution color monitors capable of displaying high resolution real-time and recorded video.

The four video cassette recorders (VCR) also require LAN compatability and remote control capability. These VCRs should have 24 hour recording and near real-time playback capability.

The video switching matrix will allow for any video input device to be connected to any video output device.

LSRF video buffering will be provided by the Space Station Video System to preclude loss of data due to broken communications. Video buffering will not prevent the real-time transmission of data to the user.

3.3.2.3 LSRF Voice System Requirements, Design and Operation

The LSRF voice system requires a minimum of three voice channels, synchronized with video data, to support simultaneous experiment operation and provide for experiment ground support by principal investigators. Voice data should be recorded onboard for downlink to the ground support facility for historical accounting of onboard activities.

Onboard crew activites require voice activated wireless headsets to allow for hands free, unencumbered communications between crew members in remote onboard locations and ground support personnel. Access to crew voice communications should be limited and subject to privacy requirements of the investigators and the crew.

3.3.3 Crew Requirements

Crew operational requirements have been identified for each of four 180 day construction phases which will be used to integrate hardware and produce meaningful science collection based on the hardware and crew resources available. Crew requirement assessments are based on the reference complements of life sciences experiments identified for each phase.

3.3.3.1 Crew Time and Availability

Crew time per phase was obtained by totaling the time required to perform the selected individual experiment investigations.

Crew availability was based on the following:

(1) Crew complement of six

(2) One Life Scientist available half-time

(3) Four remaining crewmembers available half a day/week as subjects and operator

(4) One crewmember available half a day/week as subject/operator and one hour/day for six days for equipment servicing/maintenance.

The crew availability totals 72 LSRF crew hours per week and the crew availability total for science research on a 180 day mission for six crewmembers is 1872 hours per mission.

Figure 3.3.3.1 presents a Reference Mission Space Station LSRF 7-day duty cycle.

A significant portion of available crew time will be utilized in the early construction phases for hardware integration and test. In this report, the total crew availability of 72 hours was scheduled for research and maintenance/servicing time. Information required for a definitive crew time analysis of hardware integration and test was not available for this report and therefore was not included.

Crew time requirement estimates have been based on the LSRF utilizing highly automated equipment. An operational assessment was performed for BmRP human crew time requirements which were derived from experiment protocols. See Appendix A. The "Greenbook" estimates were used to derive crew time requirements for the BRP non-human investigations.

For most of the investigations the role of the Life Scientist (operator) was considered to be that of assuring science data quality and performing science contingency planning in addition to operating equipment to obtain data on subjects. Human investigations utilize crewmembers as subjects, technicians or operators when necessary. Crew time required for equipment calibration and ground communication was included in the protocol times. Crew servicing of the plant

REFERENCE MISSION SPACE STATION 7-DAY DUTY CYCLE

Revised: 11/4/86 DD

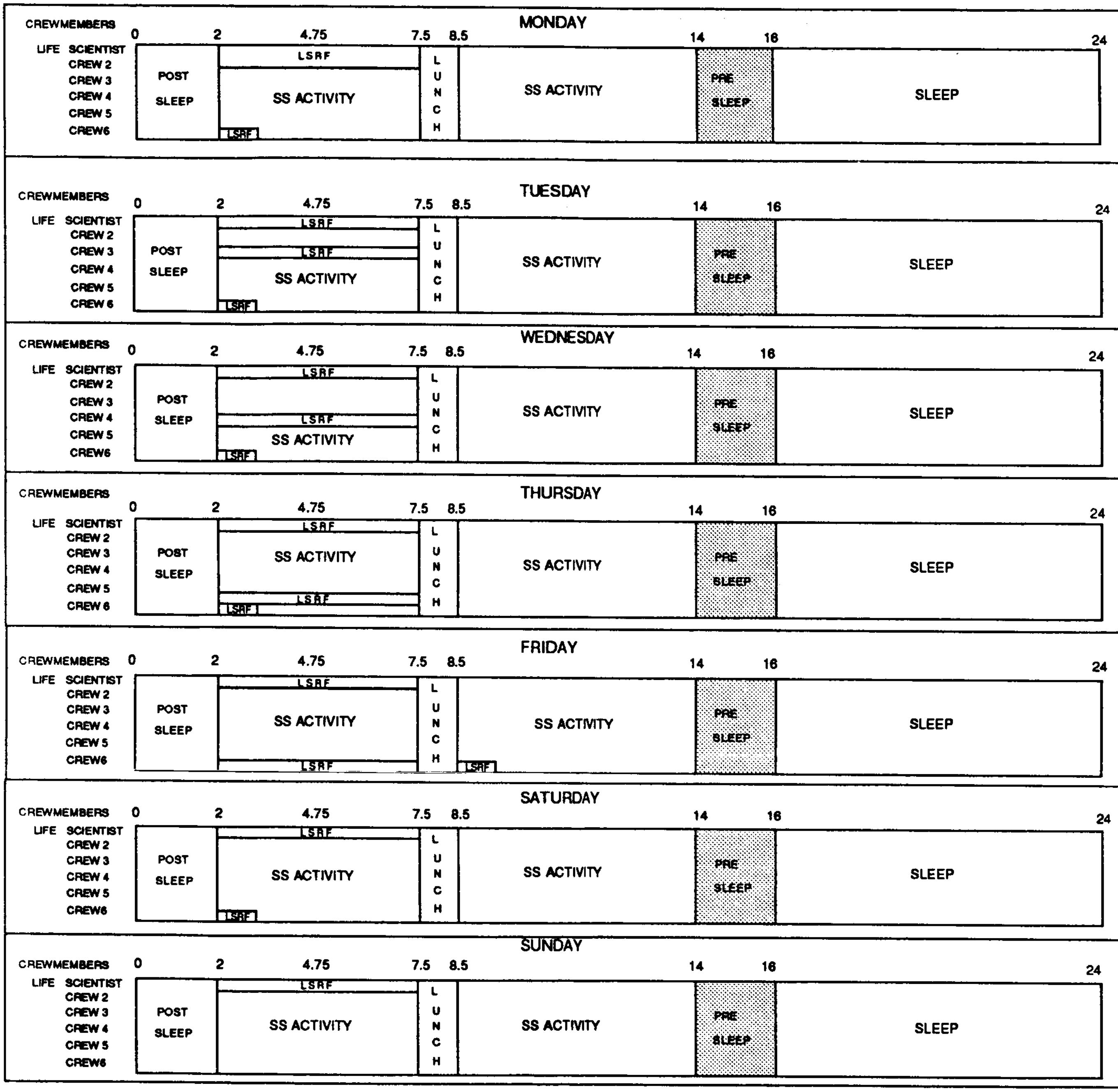


Figure 3.3.3.1

and animal holding facilities, monitoring plants and animals, and communication with principal investigators was considered for BRP experiments. A separate line item identifies plant and animal holding facility servicing requirements. Cross-utilization of resources, to include hardware and crew, has been considered in this report.

3.3.3.2 Crew Time Requirements by Phase

The investigations for each phase are defined in Appendix A and B.

Phase One, which includes six human subjects and thirty six rodents (second 90 days), utilizes the first five weeks of operation for hardware integration. The reference experiment complement identified requires a total 1039 crew hours.

Phase Two, which includes six human subjects and 48 rodents, utilizes the first four weeks of operation for hardware integration. Experiments are performed during this phase depending on equipment and crew availability. The reference experiment complement identified requires a total 1546.3 crew hours.

Phase Three, which includes six human subjects, 48 rodents, one primate and plants, utilizes the first three weeks of operation for hardware integration. Experiments are performed during this phase depending on equipment and crew availability. The reference experiment complement identified requires a total 1568.4 crew hours.

Phase Four, which includes six human subjects, 48 rodents, two primates and plants, utilizes the first two weeks of operation for hardware integration. Experiments are performed during this phase depending on equipment and crew availability. The reference experiment complement identified requires a total 1953.8 crew hours.

3.3.3.3 Crew Training Requirements

Crew training requirements are based on the reference complement of life sciences investigations for each phase. These requirements are detailed for each

180 day phase in Appendices C,D,E, and F. There are three different types of training defined below:

(1) TASK TRAINING instructs the operator in the required individual investigation protocol tasks.

(2) PHASE TRAINING provides for the organization of individual tasks into a complete investigation protocol.

(3) INTEGRATED TRAINING allows complete investigation protocols to be organized into a complete life sciences mission scenario.

Phase and Integrated training require an estimated 80 additional hours of crew training time. Task training will be supplemented by a generic training program in basic science laboratory skills common to a wide range of potential science investigations. Training time may be reduced if common task requirements can be identified depending on the skill mix required for the proposed investigation protocols.

Training required to support the transfer of experiment hardware to and from the logistics module or resupply vehicle, rack installation and integration, hardware checkout, science verification, preventative maintenance, diagnostics, or component repair has not been considered in this report.

3.3.3.4 Crew Skill Mix Requirements By Phase

Crew skill mix requirements are presented in Appendices C,D,E, and F for each 180 day phase based on the tasks required to support the investigations for each phase. These tasks include small animal surgery, animal care and handling, standard laboratory procedures, operation of standard laboratory equipment, plant care and handling, and experiment specific hardware operations. In addition, the crew will be required to configure, integrate and checkout experiment hardware in the LSRF rack locations. The crew should be trained in the laboratory skills necessary to support these activities. One crew member should be a skilled technician to perform equipment servicing and maintenance, and one Life Scientist should be available on each phase.

Phase one requires the crew be trained to perform standard laboratory procedures and operate standard laboratory equipment and specific hardware to support human investigations.

Phases two through four require the crew be trained to perform small animial surgery, animal and plant care and handling, in addition to phase one requirements.

3.3.3.5 Crew Training Requirements By Phase

Phase one, which includes six human subjects and 36 rodent specimens (second 90 days), will require:

(1) Total of 290 crew hours for investigation unique task training for designated operators.

(2) Total of 131 crew hours for human investigation task training.

(3) Total of 192 crew hours for generic Life Sciences Laboratory training for designated operators.

(4) Total of 80 crew hours for phase and integrated training.

Phase two, which includes six human subjects and 48 rodents, will require the following crew time:

(1) Total of 480 crew hours for investigation unique task training for designated operators.

(2) Total of 188 crew hours for human investigation task training.

(3) Total of 336 crew hours for generic Life Sciences Laboratory training for designated operators.

(4) Total of 80 crew hours for phase and integrated training.

Phase three, which includes six human subjects, 48 rodents, one primate, and plants will require the following crew time:

(1) Total of 342 crew hours for investigation unique task training for designated operators.

(2) Total of 175 crew hours for human investigation task training.

(3) Total of 336 crew hours for generic Life Sciences Laboratory training for designated operators.

(4) Total of 80 crew hours for phase and integrated training.

Phase four, which includes six human subjects, 48 rodents, 2 primates, and plants requires the following crew time:

(1) Total of 522 crew hours for investigation unique task training for designated operators.

(2) Total of 123 crew hours for human investigation task training.

(3) Total of 336 crew hours for generic Life Sciences Laboratory training for designated operators.

(4) Total of 80 crew hours for phase and integrated training.

4.0 SUMMARY

The Life Sciences Research Facility will be fully operational after all hardware has been integrated, checked and verified over the four construction phases. The capabilities of the LSRF should evolve to meet the investigation requirements of future Life Science investigators in conjuction with NASA's long term requirement of manned exploration of space.

The Life Science Program must optimize Space Station resources of crew time, equipment, power and logistics to accomplish maximum science return on the investment in space exploration. This mission scenario is hypothetical and is only one of a multitude of investigation combinations possible using experiments from the Greenbook and Bluebook. Follow-on in-depth analyses are necessary to define the requirements for integrated experiments which optimize sample/specimen sharing, crew time, subject parameter sharing and equipment.

The data section and BRP experiment descriptions should be refined to include specific digital or analog data requirements for individual hardware items. Additional studies should require expanded protocol formats, and define peak power and thermal loads based on equipment on/off usage schedules. Investigators should conceptualize experiment requirements in detail and define the specific operations required to accomplish their experiment goals.

Additional follow-on studies should be conducted for the applications of Artificial Intelligence and Robotics in support of the Life Sciences Research Facility and ground support systems to keep the Life Sciences community abreast of technological advances that will be incorporated in the Space Station.

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APPENDIX A

INVESTIGATIONS

APPENDIX A TABLE OF CONTENTS

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Effect of Spaceflight on Cardiovascular Control in Rhesus Monkeys; II. Hemodynamic Responses to Volume Changes (CS-B)

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PHASED SEQUENCE EXPERIMENT MATRIX
(180 Day Scenarios)
SUMMARY BmRP

Expt.	L-1	L-2	L-3	L-4	POST L-4*
a	X	X		X	X
b	X	X		X	X
c	X	X		X	X
d		X		X	X
e	X	X		X	X
f	X		X	X	X
g	X		X		X
h					X
i,j	X	X		X	X
k		X	X		X
l		X	X	X	X
m		X	X		X
n				X	X
o	X		X	X	X
p	X		X	X	X
q	X		X	X	X
r					X
s					X
t	X	X		X	X
u1					X
u2					X
v,w	X		X		X
x	X			X	X
y,z	X		X	X	X
aa		X	X		X
ab,ac	X	X		X	X
ad		X	X		X
ah		X	X		X
ai,aj	X		X	X	X

*REPRESENTS EXPERIMENT OPPORTUNITY BASED ON EQUIPMENT AVAILABILITY

PHASED SEQUENCE EXPERIMENT MATRIX

(180 Day Scenarios)

Summary - BRP

Expt.	L-1	L-2	L-3	L-4	POST L-4*
CH-A				X	X
CH-B				X	X
CH-C					**
CH-D		X			X
CH-G					**
CH-H		X			X
CS-A				X	X
CS-B				X	X
CS-C				X	X
CS-D				X	X
CS-E				X	X
RA-A	X				X
RA-D			X		X
RA-E			X		X
RA-F			X		X
RA-G			X		X
RA-H		X			X
RA-I	X				X
RA-K		X			X
RA-L	X				X
IM-A	X				X
IM-B	X				X
IM-C				X	X
MR/CB-A		X			X
MR/CB-C		X			X
MR/CB-D		X			X
PL-A			X		X
PL-B			X		X
PL-E			X		X
PL-I			X		X
MS/F-A				X	X
MS/F-B			X		X
MS/F-C				X	X
MS/F-D		X			X
E/FE-A					**
NS-A		X			X
NS-D		X			X
NS-I				X	X

* Represents experiment opportunity based on equipment availability.
** Requires metabolic cages which require long term development.

DISCIPLINE: Calcium Homeostasis (a)

SESSION TITLE: Metabolic Balance for Calcium and Other Bone Related Constituents

OBJECTIVE: To determine the percent calcium absorption from food and the amount of calcium transferred into the intestine using double labeled calcium isotope.

PERFORMANCE REQUIREMENTS:

(1) Ca^{46} will be ingested and Ca^{48} injected IV for six subjects once/month

(2) Blood samples will be collected via heparin lock at 4 & 10 hrs, follow up draws at 20, 44, 68, 92, 116, 140, 164, and 188 hours.

(3) Stool will be collected each 24 hours for 8 days. Stool marking by ingesting polyethylene glycol, 500 mg, every 8 hours for 8 days. Stool samples freeze dried and stored at -4°C.

(4) Urine samples before experiment and 24 hour samples daily for 8 days. Measured, aliquoted and frozen.

(5) Phased Sequence Requirements: L-1, 2, 4; perform urine/feces collection; 8.5 hrs/perf.

EQUIPMENT:

ITEM	QTY
pH/Specific Ion Analyzer	1
Feces Collection System	1
Urine Collection System	1
Small Mass Measurement Device	1
Freeze-Dryer	1
Freezer	1
Standard Lab Centrifuge	1
Urine Sample Vials	162
Feces Sample Vials	144
Radioisotopes	1
Blood Collection Disposables	180
Blood Collection Reusables	1
Blood Collection Tubes	180

STEP DESCRIPTION	TIME
Initial void/frozen	5' x 6s = 30'
Insert catheter obtain bckg. sample	15' (s/o) x 6s = 180'
Ingest Ca^{46}	1' x 6s = 6'
Inject Ca^{48} IV	5' (s/o) x 6s = 60'
Blood Draw 4 & 10 hrs.	4' (s/o) x 6s = 48' x 2 BD = 96'
Refrigerate/centrifuge run	15' (o) x 6s = 90'
Blood Draws	4' (s/o) x 6s x 8 perf. = 384'
20,44,68,92 hrs.	
116,140,164,188 hrs.	
Refrigeration	4' x 8 BD x 6s = 192'
Centrifugation/sample prep.	15' x 8 BD x 6s = 720'
Stool coll./prep.	5' x 6s x 8 perf. = 240'
Ingest polyethylene	
Void/freeze	5' x 6s x 8 perf. = 240'
	Total = 2238 min. x 3 perf. = 111.9 crew hrs. total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

COMMENTS:

Assume blood draw operator can access other crew during non-life sciences activities; stool collection, 24-hr voids and glycol ingestion not charged off to life science crew time. Catheter removal after 20 hour draw.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Calcium Homeostasis (b)

SESSION TITLE: Bone Density Measurements

OBJECTIVE: To determine the rates of bone loss during long term spaceflight and to measure the loss in various parts of the skeleton in order to determine which parts of the skeleton are most gravity dependent.

PERFORMANCE REQUIREMENTS:

(1) Calibration performed once per two weeks, prior to studies.

(2) Densitometry performed every two weeks with six subjects; operator not required for density determination.

(3) Phased Sequence Requirements: L-1, 2, 4; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Bone Densitometer	1
Passive Dosimeter	1

STEP DESCRIPTION	TIME
Calibrate Bone Densitometer/Recordkeeping	30 Min.(op)
Determine Density of Subject Bones	
(1) Calcaneus	8 Min.(s)
(2) (Distal) Tibia	8 Min.(s)
(3) (Cervical) Vertebrae	8 Min.(s)
(4) (Mid-Shaft) Radius	8 Min.(s)

Total = 32' x 6s = 192' + 30' = 222'
(6s/one perf.)
6 weeks = 1332' = 22.2 crew hrs.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Calcium Homeostasis (c)

SESSION TITLE: Measurement of Renal Stone Risk Factors

OBJECTIVE: To determine and measure the risk factors for renal stone development during spaceflight.

PERFORMANCE REQUIREMENTS:

(1) Once per week a 24 hour urine collection will be performed on six subjects. Total urine volume will be measured and an aliquot of urine will be frozen for ground analysis.

(2) A microscopic examination and osmolality measurement performed.

(3) Voids in experiment - "a" may be utilized (3 total)

(4) Ion selective chromatograph to be developed.

(5) Phased Sequence Requirements: L-1, 2, 4; perform urine collection; 6.5 hrs/perf.

EQUIPMENT:

ITEM	QTY
Urine Collection System	1
Urine Slide Prep Kit	1
Inflight Digitizing System	1
Osmometer	1
Freezer	1
Urine Sample Vials	78
Ion Selective Chromatograph	1
Work Top	1

STEP DESCRIPTION:	TIME
Void/sample prep.	5 Min./(Subject) x 6s x 13 weeks = 390'
Sample Preparation (Urine Slides)	5 Min./Slide (op.) - 5' x 6s x 13 weeks = 390'
Sample Analysis (a) Digital Microscope	5 Min./Slide (op.) - 5' x 6s x 13 weeks = 390'
(b) Osmometer	5 Min./Slide (op.) - 5' x 6s x 13 weeks = 390'
	Total = 1560' = 26.0 crew hrs/ 6 subj/13 wks

COMMENTS:

Assume 24 hr. voids not charged; only void utilized for inflight analysis is charged.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Cardiovascular System (d)

SESSION TITLE: Full Assessment of Hemodynamic Alterations

OBJECTIVE: To quantify changes in the cardiac and peripheral muscular responses to simulated orthostasis (LBNP) and other stresses via non-invasive techniques.

PERFORMANCE REQUIREMENTS:

(1) Once per week optimally twice per week for each subject.
(2) 24-Hr urine sample - covered in "a" and "c".
(3) 4 Levels of LBNP
(4) Phased Sequence Requirements: L-2, 4; perform BMMD, echo/ultrasound and LBNP; 6.27 hrs/perf.

EQUIPMENT:

ITEM	QTY
Freezer	1
24 Hr. Urine Collection System	1
Refrigerated Centrifuge	1
Multipurpose Work Bench	1
BMMD	1
LBNP Device	1
Echocardiograph/Ultrasound Imaging System	1
Subject Restraint System	1
Multichannel SCR	1
Centrifugal Hematology System	1
Urine Sample Vials	78
Medical Emergency Life Support Kit	2
ECG Electrode Kits	78
Echo Gel	1
Environmental Monitor	1
Display Video Monitor	1
Blood Collection Disposables	78
Blood Collection Reusables	1
Blood Collection Tubes	78
Physiologic Hemodynamic Assessment Device	1
Work Top	1

STEP DESCRIPTION:	TIME
Unstow/Set-Up	15 Min.(op.)
BMMD Calibration	15 Min.(op.)
Measurement	6 Min. (s) x 6s = 36'
Ambient Echo/Ultrasound BP, HR, Visceral/Skeletal blood flow	10 Min. (s/o) x 6s = 120'
Blood	4 Min. (s/o) x 6s = 48'
Refrigerate	4 Min. (o) x 6 = 24'
Centrifugation	15 Min. (o) x 6 = 90'
Lower Body Negative Pressure	
Echo/Ultrasound, BP, HR, Visceral/Skeletal Blood Flow	30 Min. (s) x 6s = 180'
Stow/Clean-Up	10 Min.(op)
	9.0 Hrs/performance x 13 wks = 116.6 Hrs (6 subjects)

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Cardiovascular System (e)

SESSION TITLE: Dysrhythmia Assessment

OBJECTIVE: Use advanced non-invasive techniques to determine incidence, severity, and nature of inflight cardiac electrical disturbances which may limit strenuous exercise and EVA.

PERFORMANCE REQUIREMENTS:

(1) Once per week, optimally twice per week/subject
(2) Phased Sequence Requirements: L-1, 2, 4; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Multichannel SCR	1
Display Video Monitor	1
SCR Paper (Rolls)	8
Medical Emergency Life Support Kit	1
Multipurpose Work Bench	1
ECG - Electrode Kit	78
Centrifugal Hematology System	1
Physiologic Hemodynamic Assessment Device	1
Work Top	1

STEP DESCRIPTION:	TIME
Unstow/Set-Up/Recording	10 Min.(op.) = 10'
Subject Attach	5 Min. (s) x 6s = 30'
Dysrhythmia Assessment	20 Min. (s) x 6s = 120'
Detach	5 Min. (s) x 6s = 30'
	3.2 Hrs/performance x 13 wks = 41.2 hrs. total (6 subjects)

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Muscle Physiology (f)

SESSION TITLE: Measurement of Inflight Neuromuscular Activity

OBJECTIVE: To determine what movements are performed during normal inflight activities as opposed to those performed in one-g.

PERFORMANCE REQUIREMENTS:

(1) Subject will attach and wear the appropriate hardware over a 24 hour period while performing normal on-orbit activities.

(2) Performed once per week per subject.

(3) Calibration weekly.

(4) Phased Sequence Requirements: L-1, 3, 4; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Surface EMG	1
EMG Electrode Kit (13 wks x 6 per week)	78
Force Measurement Device	1
Goniometer and Recorder	1
Accelerometer and Recorder	1
Computer Terminal	1

STEP DESCRIPTION:	TIME
Calibration	10 Min. (op.) = 10'
Unstow EMG Set, EMG Kit, Goniometer Set, Accelerometer Set	5 Min. (s) x 6s = 30'
Don EMG/goniometer Hardware	5 Min. (s) x 6s = 30'
Don Accelerometer/Recorder	5 Min. (s) x 6s = 30'
Don Force Measurement Device	5 Min. (s) x 6s = 30'
Remove EMG Electrodes, Goniometer, Accelerometer and Force Measurement Device	5 Min. (s) x 6s = 30'
Stow EMG Set, EMG Kit, Goniometer, Accelerometer and Force Measurement Device	5 Min. (s) x 6s = 30'
	190 Min./6 subj./perf. Total: 190 min. x 13 weeks = 2470 min. = 41.2 crew hrs.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Muscle Physiology (g)

SESSION TITLE: Neuromuscular Potential Output during Spaceflight

OBJECTIVE: To functionally assess neuromuscular output inflight as opposed to a 1-g environment.

PERFORMANCE REQUIREMENTS:

(1) The subject will attach EMG electrodes to each of four muscle groups (knee flexors, knee extensors, dorsal foot flexors, and plantar foot flexors).

(2) Using the isokinetic measurement device the subject will exert maximum force with each muscle group at a target velocity of 240 degrees/sec. for 3 repetitions each.

(3) Peformed once per week; calibration and unstow weekly.

(4) Phased Sequence Requirements: L-1, 3; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Surface EMG	1
Isokinetic Measurement Device	1
EMG Electrode Kit (13 wks x 6 per week)	78
Voice Recorders	6
Voice Recorder Cassettes	TBD

STEP DESCRIPTION:	TIME
Set-Up and Calibrate IMD	10 Min. (op.) = 10'
Unstow EMG Kit and Hardware/Recording	5 Min. (op.) = 5'
Don EMG Electrodes	5 Min. (s) x 6 = 30'
Perform Force Measurement x 3	10 Min. (s) x 6 = 60'
Remove EMG Electrodes/Stow	5 Min. (s) x 6 = 30'
	135 Min./6 subj./perf.
	Total: 135 min. x 13 = 1755 min. = 29.3 crew hrs.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Muscle Physiology (h)

SESSION TITLE: Neuromuscular Fatigability and Metabolic Potential of Muscles during Spaceflight

OBJECTIVE: To evaluate neuromuscular fatigability and metabolic potential of exercised muscle groups in zero-gravity.

PERFORMANCE REQUIREMENTS:

(1) To produce a maximum force effort for a 2 minute period for each of 4 muscle groups.

(2) Force measurements are taken 1 per second.

(3) Performed once weekly; calibration and unstow weekly.

(4) Phased Sequence Requirements: Perform after L-4.

EQUIPMENT:

ITEM	QTY
Isokinetic Measurement Device	1
Surface EMG	1
EMG Electrode Kit (13 wks x 6 per wk)	78
Blood Collection Reusables	1
Blood Collection Tubes	78
Blood Collection Disposables	78
Standard Lab Centrifuge	1
Freezer	1

STEP DESCRIPTION:	TIME
Unstow EMG Kit, Blood Collection Supplies	5 Min.(op.)
Set-Up and Calibrate IMD	10 Min.(op.)
Don EMG Electrodes	5 Min.(s) x 6 = 30'
Perform Force Protocol (2 Min x 4 Groups + Change)	10 Min.(s) x 6 = 60'
Perform Blood Draw	4 Min.(s/o) x 6 = 48'
Sample Processing and Centrifuging	15 Min.(op.) x 6 = 90'
Remove EMG Electrodes/Stow	5 Min.(s) x 6 = 30'
	273 Min./6 subj./perf. 59.2 Hrs Total (13 Weeks)

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Radiation Effects (i,j)

SESSION TITLE: Chromosomal Aberration Study and Dosimetry for all Life Sciences Subjects

OBJECTIVE: Correlate crew chromosomal aberrations with spaceflight radiation dosage and heavy ion exposure.

PERFORMANCE REQUIREMENTS:

(1) i - Once/Week for 4 weeks
j - Weekly

(2) Blood Draws/6 Crewmembers (i)

(3) Microscopic Image Recorded and Downlinked (i)

(4) Dosimetry (j)

(5) Phased Sequence Requirements: L-1, 2, 4; Perform (j) dosimetry; .5 hr/perf.

EQUIPMENT:

ITEM	QTY (i)	QTY (j)
Centrifuge (37°C)	1	1
Microdosimetric Dosimeter	1	1
Proton & Heavy Ion Spectrometer	1	1
Thermoluminescent Dosimeter (TLD)	1	1
TLD Reader	1	1
Blood Collection Reusables	1	1
Blood Collection Disposables	24	78
Blood Collection Tubes	24	78
Standard Lab Centrifuge	1	1
Phycol and PBS Consumables Kits	24	78
Cell Handling Accessories	24	78
Incubator (5% CO_2, 37°C)	1	1
Chromosomal Slide Prep Device	1	1
Inflight Digitizing System	1	1
Work Top	1	1

STEP DESCRIPTION:	TIME
Dosimeter/Spectrometer Maintenance (j)	30 Min./Week (op.) 6.5 Hrs/Mission
Blood Draw (i)	4 Min.(s/o) x 6 = 48'
Centrifugation (i)	15 Min.(op) x 6 = 90'
Slide Prep/Read (i)	30 Min.(op) x 6 = 180'
	5.3 Hrs w/o maint. 5.3 x 4 = 21.2 + 6.5= 27.7 hrs total mission

COMMENTS:

This combines 2 investigations.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Exercise Physiology (k)

SESSION TITLE: Muscle Adaptation and Readaptation (Muscle Performance Changes)

OBJECTIVE: To delineate the type, extent and time course of changes that occur during the skeletal muscle system during long-term spaceflight.

PERFORMANCE REQUIREMENTS:

(1) Weekly

(2) Six subjects

(3) Isokinetic exercise at three different velocities while measuring surface EMG's on both legs, both arms and torso.

(4) Unstow and Calibration once per week.

(5) Phased Sequence Requirements: L-2, 3; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Isokinetic Measuring Device	1
Surface EMG	1
EMG Electrode Kit	78
Nerve Conduction Velocity Tester	1
Nerve Electrode Kit	78
Computer Terminal	1
Voice Recorder	6
Voice Recorder Cassettes	TBD

STEP DESCRIPTION:	TIME
Set-Up/Calibrate Isokinetic Meas. Device	10 Min.(op)
Unstow EMG, EMG Kit	5 Min.(op)
Prepare Subject (attach leads, etc.)	5 Min.(s) x 6 = 30'
Perform Isokinetic Measurement	40 Min.(s) x 6 = 240'
Surface EMG Test (Conduction Velocity) Includes Set-Up	15 Min.(s) x 6 = 90'
Detach/Stow	10 Min.(s) x 6 = 60'
	7.3 Hrs/6 Subj./Perf.
	94.3 Hrs total/13 Perf.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Exercise Physiology (I)

SESSION TITLE: Exercise Program for Spaceflight

OBJECTIVE: To develop and test exercise programs designed to prevent or minimize the unwanted adaptive physiological changes that occur during long duration spaceflight.

PERFORMANCE REQUIREMENTS:

(1) Once per day each of the six crewmembers will perform 30 min. of aerobic and 30 min. of anaerobic exercise.

(2) Workload, forces and velocity/number of repetitions will be measured continuously during exercise.

(3) Unstow and calibration once per week.

(4) Phased Sequence Requirements: L-2, 3, 4; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Anaerobic Exercise Device	1
Treadmill	1
Bicycle Ergometer	1
Rowing Machine	1
Heart Rate Monitor	1
Physiologic Hemodynamic Assessment Device	1

STEP DESCRIPTION:	TIME
Unstow/Set-Up Exercise Equipment	10 Min.(op)
Prepare for Aerobic Exercise	
(a) Set-Up/Calibrate Equipment	15 Min.(op)
(b) Prepare Subject	5 Min.(s) x 6 = 30'
Perform Aerobic Exercise	30 Min.(s) x 6 = 180'
Anaerobic Exercise	30 Min.(s) x 6 = 180'
Detach/Stow Equipment	10 Min.(s) x 6 = 60'
	7.9 Hrs/6 Subj/Perf
	711 Hrs total (90 Perf.)

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Endocrinology/Fluid Electrolytes (m)

SESSION TITLE: Measurement of Venous Pressure and Plasma Volume Early and Long Duration Effects of Weightlessness

OBJECTIVE: To determine whether a cause-effect relationship exists, between decreases in venous pressure and plasma volume during early spaceflights.

PERFORMANCE REQUIREMENTS:

I. Plasma Volume Measurements on 6 subjects on FD1, FD3 (or 4), FD10, FD30, FD50, FD70
(1) Requires background blood sample and sample 30 minute post-injection
(2) Phased Sequence Requirements: Perform after L-4

II. Venous pressure measurements on 6 subjects
(1) FD1 hourly measurements for 8 hours
(2) FD2-7 single measurement per day.
(3) Weekly measurement for weeks 2-13.
(4) Phased Sequence Requirements: L-2, 3; perform VP measurements; 2.8 hrs. week 1, .2 hrs. each subsequent week.

EQUIPMENT:

ITEM	QTY
Physiologic Hemodynamic Assessment Device	1
Venous Pressure Disposables	156
I 25-Iodine Isotope Kit/Shield	6
Blood Collection Reusables	1
Blood Collection Tubes	72
Blood Collection Disposables	72
Standard Lab Centrifuge	1
Gamma Counter	1
Freezer	1

STEP DESCRIPTION:	TIME
Plasma Volume	
Unstow/Set-Up	10 Min.(op) x 6 perf. = 60'
Background blood draw/isotope injection week 1 (2 perf.)	7 Min. (s/o) x 6s x 2 perf. = 168'
Blood draw post-injection week 1 (2 perf.)	4 Min. (s/o) x 6s x 2 perf. = 96'
Gamma Counter - week 1	20 Min. (op) x 6s x 2 perf. = 240'
Background blood draw/isotope injection days 10, 30, 50, 70	7 Min. (s/o) x 6s x 4 perf. = 336'
Blood draw post-injection days 10, 30, 50, 70	4 Min. (s/o) x 6s x 4 perf. = 192'
Gamma Counter - days 10, 30, 50, 70	20 Min. (op) x 6s x 4 perf. = 480'
Stow	10 Min. (op) x 6 perf. = 60'
	TOTAL = 1632'/6s/6 perf.
Venous Pressure	
VP Measurement - Week 1	1 Min. (s/o) x 6s x 14 perf. = 168'
VP Measurement - Weeks 2-13	1 Min. (s/o) x 6s x 12 perf.= 144'
	TOTAL = 312'/6s/13 wks
	TOTAL TIME = 32.4 Crew Hours

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Endocrinology/Fluid Electrolytes (n)

SESSION TITLE: Circadian Rhythm of Plasma Hormones and Serum Electrolytes during Weightlessness

OBJECTIVE: To determine whether the circadian cycling of hormone/electrolyte levels change in routine spaceflight relative to preflight ground-based studies.

PERFORMANCE REQUIREMENTS:

(1) Every three days for 60 days for each of 6 subjects (20 Perf.).

(2) 24 hour urine collection for each of 6 subjects; 4 voids x 20 days - 80 voids/subj.

(3) Blood every 4 hours for 28 hours; 7BD x 20 Perfs. = 140BD/Subj.

(4) Phased Sequence Requirements: L-3,4; perform urine collection only, 2 hrs/perf.

EQUIPMENT:

ITEM	QTY
Heparin Lock Kit	140
Blood Collection Reusables	1
Blood Collection Tubes	840 (10 ml vial)
Blood Collection Disposables	840
Standard Lab Centrifuge	1
Freezer	1
24 Hour Urine Collection System	1
Urine Sample Vials	480 (20 ml vial)

STEP DESCRIPTION:	TIME
Unstow/Set-Up	10 Min.(op) x 20 perf = 200'
Blood Draw (6 crew, every 4 hours for 28 hours)	4 Min./op.(s/o) x 6s x 140BD = 6720'
Centrifuge Samples	15 Min.(op)x20perf. =300'
Collect Urine Sample (24 hours)/Refrigerate	5 Min.(s) x 6s x 80 voids = 2400'
Stow/Clean-Up	5 Min.(op) x 20 perf = 100'
	8.1 Hrs/6 Subj./perf.
	162 hours total (20 perf.)

336 Min. BD + 120 Min. Voids + 30 Min. Centrifuge/Stow = 8.1 Hrs/6 Subj/Perf.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Behavioral Research (o)

SESSION TITLE: Psychosocial Support

OBJECTIVE: To assess the effectiveness of individually tailored psychosocial support methods in actual spaceflight settings.

PERFORMANCE REQUIREMENTS:

(1) Six subjects

(2) 13 sessions/mission (1/week)

(3) Each crewperson evaluates his/her individually tailored psychosocial support measure by means of a computer generated questionaire.

(4) Phased Sequence Requirements: L-1, 3, 4; perform entire protocol.

EQUIPMENT:	ITEM	QTY
	Computer terminal	1

STEP DESCRIPTION:	TIME
Evaluation of psychosocial support measures	15 Min.
	1.5 Hrs/performance (6 subjects) 19.5 Hrs/13 Perf.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Behavioral Research (p)

SESSION TITLE: Group Interaction, Compatibility, and Effectiveness

OBJECTIVE: To compare preflight with inflight individual attitudinal data to assess the effect of space station duty on group interactions and effectiveness.

PERFORMANCE REQUIREMENTS:

(1) Six subjects

(2) 13 sessions/mission (1/week)

(3) Attitudinal data will be collected from each crewperson during a 10 minute once/week session via computer terminal interaction to be stored for postflight analysis.

(4) Assume hard disc for data storage.

(5) Phased Sequence Requirements: L-1, 3, 4; perform entire protocol.

EQUIPMENT:	ITEM	QTY
	Computer terminal	1

STEP DESCRIPTION:	TIME
Attitude Report	10 Min.
	1.0 Hr/performance (6 subjects)
	13.0 Hrs/13 Perf.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Behavioral Research (q)

SESSION TITLE: Problem Solving

OBJECTIVE: To evaluate individual aspects of crew interaction preflight and apply what is learned to increase flight crew efficiency in routine operations and problem solving.

PERFORMANCE REQUIREMENTS:

(1) Six subjects

(2) 13 sessions/mission (1/week)

(3) One 3 hour problem solving group session will be conducted once/week to be stored for postflight analysis.

(4) Phased Sequence Requirements: L-1, 3, 4; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Video camera	1
Microphone	1
Video recorder	1
Video cassettes	13
Video Monitor Display	1

STEP DESCRIPTION:	TIME
Group problem solving session	30 Min.
	3.0 Hrs/performance (6 subjects)
	39.0 Hrs total (13 perf.)

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Hematology (r)

SESSION TITLE: Determine Sequential Change in Red Cell Mass, EP, Reticulocytes, and Ferritin

OBJECTIVE: Determine microgravity exposure effects on reticulocyte formation and correlate these changes with other parameters of bone marrow and peripheral blood.

PERFORMANCE REQUIREMENTS:

(1) Once per month
(2) 6 Subjects
(3) Each performance requires blood draws at 1, 2, 4, 5, 10, 21, and 26 days following ^{59}Fe injection.
(4) Phased Sequence Requirements: Perform after L-4.

EQUIPMENT:

ITEM	QTY
Blood Collection Tubes	144
Blood Collection Reusables	1
Blood Collection Disposables	144
Reticulocyte Smear Kit	3
Standard Lab Centrifuge	1
Inflight Digitizing System	1
Freezer	1
^{59}Fe Isotope Kit/Shield	3
^{51}CR Tagging Kit/Shield	1
Spectrophotometer	1
Hematocrit Centrifuge	1
Scintillation Counter	1
Heparin Lock Kit	3
Cation Exchange Resin Kit	3
Red Cell Mass Reagent Kit	3
Centrifugal Hematology System	1
Gamma Counter	1

STEP DESCRIPTION:	TIME
Unstow Kits	10 Min.(op)
Blood Draws	4 Min.(s/o) x 6 = 48'
Tag Cells (Cr^{51})	3 Min.(op) x 6 = 18'
Inject Tagged Cells (10 ml) - Break 30 Min.	4 Min.(s/o) x 6 = 48'
Draw Blood	4 Min.(s/o) x 6 = 48'
Inject ^{59}Fe	2 Min.(s/o) x 6 = 24'
Perform hematology on background blood Hgb, Hct, CBC, Reticulocyte slides, red cell count	10 Min.(op) x 6 = 60'
Stow	10 Min.(op)
	266 Min. = 4.4Hrs/6 Subj/Perf

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

Each Subsequent Draw (7)	
Unstow	5 Min.(op)
Draw Blood	4 Min.(s/o) x 6s = 48'
Centrifuge	15 Min.(op) x 6s = 90'
Stow	5 Min.(op)
	148 Min. x 7 draws = 1036 Min.
	=17.2 Hrs/6 Subj/7BD

21.6 Hrs. per performance x 3 = 3888 min. = 64.8 crew hrs total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Hematology (s)

SESSION TITLE: Determine Role of Splenic Sequestration on Disease in the Red Cell Mass

OBJECTIVE: Record the response in red cell mass during prolonged exposure microgravity in exercised and non-exercised subjects.

PERFORMANCE REQUIREMENTS:

(1) Once per month for tracer/blood work; BMMD weekly; exercise 4 times a week.
(2) 6 Subjects
(3) Each performance requires blood draws at 1, 2, 4, 5, 10, 21, and 26 days following ^{59}Fe injection.
(4) Exercise 4 times a week.
(5) BMMD
(6) Phased Sequence Requirements: Perform after L-4.

EQUIPMENT:

ITEM	QTY
Blood Collection Reusables	1
Blood Collection Tubes	144
Blood Collection Disposables	144
Evans Blue Dye Injection Kit	144
Standard Lab Centrifuge	1
Inflight Digitizing System	1
Freezer	1
^{59}Fe Kit/Shield	1
^{51}CR Tagging Kit/Shield	1
Spectrophotometer	1
Hematocrit Centrifuge	1
Scintillation Counter	1
Bicycle Ergometer	1
BMMD	1
Red Cell Mass Reagent Kit	1
Reticulocyte Smear Kit	1
Gamma Counter	1
Centrifugal Hematology System	1

STEP DESCRIPTION:	TIME
Unstow Kits	10 Min.(op)
Draw Blood	4 Min.(s/o) x 6s = 48'
Tag Cells (Cr^{51})	3 Min.(op) x 6s = 18'
Inject Tagged Cells (10 ml) - Break 30 Min.	4 Min.(s/o) x 6s = 48'
Draw Blood	4 Min.(s/o) x 6s = 48'
Inject ^{59}Fe	2 Min.(s/o) x 6s = 24'
Blood Workup	10 Min.(op) x 6s = 60'
Stow	10 Min.(op)

4.4 Hrs/6 Subj./Perf x 3 Perf.
= 13.2 Hrs.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

Each Subsequent Draw x 7 days Blood Workup	4 Min.(s/o) x 6 x 7BD = 336' 10 Min.(op) x 6 x 7BD = 420' 756 = 12.6 Hrs x 3 Perf = 37.8 Hrs.
BMMD Calibration BMMD Measure	15' (op) 6' (s) x 6 = 36' 51' x 13 weeks = 11.05 Hrs
Exercise Protocol	30 min. (4 x 13 weeks) = 1560' = 26 Hrs. x 6 subj. 156 crew hrs.

Total = 11.0 (BMMD) + 51.0 (blood) + 156.0 (exercise) = 218.0 Hrs. Total

COMMENTS:

Exercise requirements may be achieved jointly thru other protocols.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Immunology (t)

SESSION TITLE: Delayed Type Hypersensitivity

OBJECTIVE: Evaluate ability of body to produce specific antibodies in space.

PERFORMANCE REQUIREMENTS:

(1) Six subjects once per month.
(2) Inject attenuated antigen; blood draw at 8,24,28 hour intervals
(3) Blood draw once/week for following 2 weeks.
(4) Samples to be analyzed via Elisa Chemical Analysis
(5) Binding sites on reception cells will be evaluated by flow cytometry
(6) Phased Sequence Requirements: L-1, 2, 4; perform antigen injection and read arm 48 hours after w/inflight digitizing system; 2.96 hrs/perf.

EQUIPMENT:

ITEM	QTY
Inflight Digitizing System	1
Refrigerated Centrifuge	1
Standard Lab Centrifuge	1
Refrigerator	1
Elisa Analysis Chemicals	1
Spectrophotometer	1
Bone Densitometer	1
Flow Cytometer	1
Antigen Kit	1
Blood Collection Reusables	1
Blood Collection Disposable	90
Blood Collection Tubes	90
Elisa Reader	1
Contamination Container	1
Centrifuge (37^{o}C)	1

STEP DESCRIPTION:	TIME
Unstow/set up for injection	10 Min.(op)
Inject attenuated antigen (6 subjects)	4 Min.(s/o) x 6 = 48'
Blood draw (6 subjects) 8,24,28 hour intervals	4 Min.(s/o) x 6 x 3BD =144'
Blood draw - weeks 2 & 3	4 Min.(s/o) x 6 x 2BD = 96'
Centrifuge blood	15 Min.(op) x 6 x 3BD =180'
Prepare/study samples (with Elisa Chemicals)	10 Min.(op) x 6 x 3BD = 180'
- Flow Cytometry	
- Image Analysis	
	Total 658 Min. = 10.9 Hrs/6 Subj./Perf
	32.9 Hrs for 3 Perfs.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Immunology (u1)

SESSION TITLE: Blast Transformation/Protein Production

OBJECTIVE: Measure long-term inflight alterations of T and B lymphocyte response to in-vitro mitogenic challenges.

PERFORMANCE REQUIREMENTS:

(1) 4 Performances

(2) 6 Subjects

(3) Centrifuge incubated, 1-g.

(4) Phased Sequence Requirements: Perform after L-4.

EQUIPMENT:

ITEM	QTY
Centrifuge (37°C)	1
Blood Collection Reusables	1
Blood Collection Tubes	24
Blood Collection Disposables	24
Incubator	1
Mitogen Kit	1
Freezer	1
Inflight Digitizing System	1
Radioisotope Kit/Shield	1
Sample Prep Device (Fluid Transfer)	1
Contamination Container	1
Flow Cytometer	1
Cell Culture Expendables	1
Standard Lab Centrifuge	1
Laminar Flow Hood	1
Elisa Analysis Chemicals	1
Elisa Reader	1

STEP DESCRIPTION:	TIME
Unstow Kits	10 Min.(op)
Draw Blood	4 Min.(s/o) x 6 = 48'
Transfer Specimens	5 Min.(op) x 6 x 2 = 60'
Separate Cells	40 Min.(op)
Culture and Incubate Lymphocytes	20 Min.(op) x 6 = 120'
Harvest Cultures	15 Min.(op) x 6 = 90'
Cell Prep and Analysis	20 Min.(op) x 6 = 120'
Cell Prep and Digitizing	10 Min.(op) x 6 = 60'
Flow Cytometry	10 Min.(op) x 6 = 60'
	10.1 Hrs/6 Subj/Perf

608 min. x 4 = 2432 min. = 40.5 crew hrs. total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Immunology (u2)

SESSION TITLE: Phenotyping of Peripherally Circulating Blood Cells

OBJECTIVE: Measure a number of lymphocyte subsets by flow cytometry

PERFORMANCE REQUIREMENTS:

(1) 4 Performances

(2) 6 Subjects

(3) Centrifuge incubated, 1-g.

(4) Phased Sequence Requirements: Perform after L-4.

EQUIPMENT:

ITEM	QTY
Centrifuge (37°C)	1
Blood Collection Reusables	1
Blood Collection Tubes	24
Blood Collection Disposables	24
Standard Lab Centrifuge	1
Flow Cytometer	1
Sample Prep Device (Fluid Transfer)	1

STEP DESCRIPTION:	TIME
Unstow Kits	10 Min.(op)
Draw Blood	4 Min.(s/o) x 6 = 48'
Centrifuge	15 Min.(op) x 6 = 90'
Perform Cell Analysis	10 Min.(op) x 6 = 60'
	3.5 Hrs/performance (6 subjects)

208 min. x 4 performances = 832 min. = 13.9 crew hrs. total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Neuroscience (v,w)

SESSION TITLE: Vestibulo-Visual and Canalicular - Otolith Compensation

OBJECTIVE: Investigate possible visual compensation for modified otolith input during exposure to free fall using the ocular nystagmus response; investigate the differences between horizontal and vertical canals based on the differing organization and compensatory responses to angular motion about 3 axis (pitch, roll, and yaw).

PERFORMANCE REQUIREMENTS:

(1) Six subjects

(2) 13 sessions/mission (1/week)

(3) Ocular nystagmus suppression will be recorded in six subjects once per week; operator required. Eye movements affected by angular motion will be recorded in six subjects once per week, operator required.

(4) Phased Sequence Requirements: L-1, 3; perform vestibulo spinal studies L-1, 3; 5.1 hrs/perf.

EQUIPMENT:

ITEM	QTY
Helmet Interface Box	1
Rotator	1
Helmet Assembly	1
Helmet Restraint	1
EOG Signal Conditioner	1
EOG Electrode Kit	78
Recording Minioscilloscope	1
Electrode Impedance Meter	1
Experiment Control and Data Interface	1
Voice Recorder	6
Voice Recorder Cassettes	TBD
Subject Restraint System	1
Electromagnetic Tendon Striker	1
Force Resistance System	1
Amplifiers	TBD
Optokinetic Stimulus	1

STEP DESCRIPTION:	TIME
Set-Up/Calibrate	10 Min.(op)
Vestibulo Visual Test - I	17 Min.(s/o) x 6 = 204'
Test - II	14 Min.(s/o) x 6 = 168'
Canalicular-Otolith Compensation	24 Min.(s/o) x 6 = 288'
Stow	7 Min.(op)
	11.3 Hrs/performance (6 subjects)
	146.9 Hrs total

COMMENTS:

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

This combines two investigations.
Electromagnetic Tendon Striker/Leg Brace and Body Restraint is a future update pending resource inputs.

<u>EXPERIMENT SITE:</u> LSRF: √ Attached Payload: Platform:

DISCIPLINE: Neuroscience (x)

SESSION TITLE: SMS Correlates

OBJECTIVE: To correlate the experimental findings with the occurrence of space motion sickness symptoms experienced during orbital flight.

PERFORMANCE REQUIREMENTS:

(1) Six Subjects

(2) Ad Lib time estimated at 6.5 Crew Hours/Mission

(3) SMS symptoms to be recorded on flight approved checklists as they occur while on-orbit.

(4) Phased Sequence Requirements: L-1, 4; perform entire protocol.

EQUIPMENT:	ITEM	QTY
	Flight approved checklists	6

STEP DESCRIPTION:	TIME
Record onset, character, and time course of SMS Symptoms	390 Min./Mission/6 Subj. = 6.5 Hrs. Total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Pharmacokinetics (y,z)

SESSION TITLE: Drug Pharmacokinetics in Space and Evaluation of Modern Non-Invasive Methods for Clinical Drug Monitoring

OBJECTIVE: To evaluate the time course of drug concentration in the plasma and saliva following administration by various routes and to establish relationships between plasma concentration and pharmaceutical and therapeutic effects.

PERFORMANCE REQUIREMENTS:

(1) Take blood, saliva, and urine samples

(2) Process and freeze

(3) Monitor fluid and solid intake

(4) 4 times during mission for each drug administered (IM, IV, oral, rectal)

(5) 6 crewmembers

(6) Phased Sequence Requirements: L-1, 3, 4; perform drug administration with urine/saliva collection; 2.4 hrs/perf.

EQUIPMENT:

ITEM	QTY
Urine Sample Vials	288
Blood Collection Reusables	1
Blood Collection Disposables	288
Blood Collection Tubes	288
Drug Consumables Kit	1
Standard Lab Centrifuge	1
Freezer	1
Saliva Collection Units	288
24 Hour Urine Collection System	1
Spectrophotometer	1

STEP DESCRIPTION:	TIME
Administer Drug	10 Min.(s/o) x 6 = 60'
Blood Samples *	4 Min.(s/o) x 6 x 12BD = 288'
Saliva Samples *	2 Min.(s) x 12 samples = 24'
Urine Samples *	5 Min.(s) x 12 samples = 60'
Centrifugation **	15 Min.(op) x 6 = 90'

8.7 Hrs/6 Subj/Perf.
8.7 Hrs x 4 Perf = 34.8 Hrs Total

COMMENTS:

This comprises 2 investigations
Assume 1 drug
* Performed 4 times/day for 3 days
** All samples once/day

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Pulmonary Physiology (aa)

SESSION TITLE: Capability to Study Inert Gas Exchange as a Function of Time in Space

OBJECTIVE: To investigate the relationship of inert gas exchange and extended exposure to weightlessness.

PERFORMANCE REQUIREMENTS:

(1) 6 crewmen

(2) Once per week

(3) Phased Sequence Requirements: L-2, 3; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Cardiopulmonary Analyzer Flowmeter	1
BMMD	1
Gas Analyzer Mass Spectrometer	1
Mask Regulator System	1
Gas Tanks/Gas Supplies	1

STEP DESCRIPTION:	TIME
BMMD Calibration	15 Min.(op)
BMMD Meas.	6 Min.(s) x 6 = 36'
Perform Protocol	20 Min.(s) x 6 = 120'
Clean up/Stow	5 Min.(op)
	161 Min./6 Subj/Perf.

161 Min x 13 weeks = 2093 Min. = 34.9 hours total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Pulmonary Physiology (ab, ac)

SESSION TITLE: Evaluate EVA Work Output and Cardiovascular Response

OBJECTIVE: Investigate energy generated during EVA by indirect calorimetry

PERFORMANCE REQUIREMENTS:

(1) Once/week, optimally twice/week for each subject.

(2) Measurements desired when EVA occurs; EVA time not charged.

(3) Phased Sequence Requirements: L-1, 2, 4; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Doppler/Recorder	1
Doppler Expendables	1
Calorimeter	6

STEP DESCRIPTION:	TIME
Unstow/set-up	5 Min.(op)
Subject Prep.	20 Min.(s/o)
EVA workout	—
Clean up/Stow	10 Min.(s)
	35 min/subject

35 Min x 6 subj. x 13 weeks = 2730 Min. = 45.5 hours total

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Pulmonary Physiology (ad)

SESSION TITLE: Capability to Evaluate EVA Bubble Formation

OBJECTIVE: Investigate the blood and pulmonary bubble formation associated with EVA.

PERFORMANCE REQUIREMENTS:

(1) Once per week

(2) Following EVA activities once/week

(3) Doppler monitoring is continuous

(4) Phased Sequence Requirements: L-2, 3; perform doppler measurements; 1.25 hrs/perf.

EQUIPMENT:

ITEM	QTY
Doppler Expendables	1
Freezer	1
Standard Lab Centrifuge	1
Doppler Recorder	1
Blood Collection Reusables	1
Blood Collection Disposables	78
Blood Collection Tubes	78

STEP DESCRIPTION:	TIME
Unstow	10 Min.(op)
Subject Prep.	10 Min.(s/o) x 6 = 60'
Blood Draw	4 Min.(s/o) x 6 = 48'
Blood Analysis	10 Min.(op) x 6 = 60'
Stow	5 Min.(op)
	4.0 Hrs/6 Subj/Perf.
	52 Hrs Total 13 Perf.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Pulmonary Physiology (ah)

SESSION TITLE: Measure of Standard Pulmonary Function

OBJECTIVE: Investigate the loss of topographic changes in perfusion, ventilation, and lung volume after exposure to micro-g.

PERFORMANCE REQUIREMENTS:

(1) Once/week

(2) 6 subjects

(3) Calibration once/day

(4) Phased Sequence Requirements: L-2, 3; perform entire protocol.

EQUIPMENT:

ITEM	QTY
Bag-in-Box	1
Electronics Control Assembly	1
Gas Cylinder Assembly	1
Alfe Stowage Kit	1
3 Liter Calibration Syringe	1
Rebreathing Assembly	6
Spare O2 Experiment Bag Assembly	1
Spirometry Assembly	1
Gas Analyzer Mass Spectrometer	1
Multi-Channel Strip Chart Recorder	1
Physiological Monitoring System	1
Data Tapes	13
Batteries	24
SCR Paper	8
PMS Accessories	13

STEP DESCRIPTION:	TIME
Unstow/Set-Up/Calibrate	35 Min.(op)
PFT	30 Min.(s) x 6 = 180'
Stow/End Cal.	20 Min.(s) x 6 = 120'
	5.58 Hrs/6 Subj/Perf.
	72.5 Hrs. Total - 13 Perf.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

DISCIPLINE: Microbiology (ai, aj)

SESSION TITLE: Crewmember and Space Station Microbial Study

OBJECTIVE: Establish the microbial distribution and accumulation levels in the space station and determine the impact of long-term space station missions on the crewmember microflora.

PERFORMANCE REQUIREMENTS:

(1) Microbiological samples will be obtained weekly from cabin air, cabin surfaces and potable water supplies to assess microbiological build-up over the course of a 90-day mission and to evaluate antiseptic countermeasures.

(2) Microfloral samples from six crewmembers will be sampled weekly from the neck, ears, axillae, hands, navel, groin, toes, nose, and throat.

(3) Fecal samples will also be collected and analyzed for microflora.

(4) Phased Sequence Requirements: L-1, 3, 4; perform air/surface monitoring; .8 hrs/perf.

EQUIPMENT:

ITEM	QTY
Sample Swabs	754
Sample Tubes	754
Reuter Microbiology Air Sampler	1
Incubator	1
Inflight Digitizing System	1
Photomicrographic Set-Up	1
Refrigerator (4´C)	1
Agar Plates	754
Sterile Loops	754
Millipore Filtration Kit	1
Laminar Flow Hood	1
Batteries - D size	24
Millipore Filters	36
Work Top	1

STEP DESCRIPTION:	TIME
Unstow and configure centrifugal sampler	5 Min.(op)
Unstow crew microbiological sampling kit	5 Min.(op)
Obtain crewmember samples	10 Min.(s) x 6 = 60 min.
Obtain air and surface samples	20 Min.(op)
Unstow millipore filtration kit	5 Min.(op)
Load and activate incubator	10 Min.(op)
Incubate samples	60 Min. (no crew required)
Unstow and configure low power microscopes	10 Min.(op)

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

Photograph samples	15 Min.(op)
Refrigerate samples	3 Min.(op)
Stow photomicrographic set-up, centrifugal sampler, kits	10 Min.(op)
	2.4 Hrs/performance (6 subjects)
	30.9 Hrs total (13 perf.)

COMMENTS:
This combines two experiments.

EXPERIMENT SITE: LSRF: √ Attached Payload: Platform:

BIOLOGICAL RESEARCH PROJECT INVESTIGATIONS

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**

A. Discipline: Calcium Homeostasis CH-A

B. Science Objectives: CH-1

C. McDAC Expt. Ref. #/Title (Orig. or modified): Histopathogenesis of Bone Loss in Microgravity.

2. **PURPOSE/HYPOTHESIS:** To examine histopathogenesis of bone loss in microgravity. Hypothesis: (a) Massive bone loss is associated with uncontrolled activation of osteoclasts; (b) There is loss of crystallites in resorbing bone which facilitates enzymic degradation of the matrix and promotes rapid bone loss; (c) Remaining bone has a greater fraction of unmineralized collagen which inhibits new bone formation.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Mature Rhesus monkeys (*M. nemestrina* and *M. mulatta*) are known to have remodeling systems similar to man. Evaluations of bone cell types and collagen composition are required in order to define the effect of absence of 1 g mechanical loading on the remodeling system and on structural changes in the skeleton.

4. **APPROACH:**

A. Type/Number Specimens: Non-restrained adult male Rhesus monkey; 4 animals.

B. Measurements/Samples (Preflight, Inflight, Postflight): Biopsy tibial tuberosity in flight.

C. Sample Analysis (Inflight, Postflight): Tissue to be fixed in neutral formalin for 2 - 3 days and then in ethanol. Analysis to be performed post-flight.

D. Expt. Controls (Inflight, Ground-based): Ground based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**

A. Special Equipment (other than common items): Large primate holding and research facility.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 10 hours.

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Calcium Homeostasis CH-B

   B. Science Objectives: CH-2

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Sex Differences as a Factor in Loss of Bone from Different Skeletal Sites

2. **PURPOSE/HYPOTHESIS:** To investigate if sex differences determine rate of loss of mineral from different skeletal sites. Hypothesis: As long as normal ovarian function is maintained in females, there will be no differences between sexes in bone mineral alterations in radius - ulna, tibia, lumbar vertebra in microgravity environments.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Lack of ovarian function in mature Rhesus monkeys is known to increase rate of vertebral bone loss in the animal as is observed with postmenopausal patients. Evaluation of bone mineral content during spaceflight in relation to indices of ovarian function is required to determine potential sex-related effects of space flight on the human skeleton.

4. **APPROACH:**
   A. Type/Number Specimens: Non-restrained adult Rhesus monkeys; 4 male; 4 female: tests to be performed monthly.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Forty-eight hour urine sample collected in metabolic balance study and frozen for post-flight analysis. Bone mineral content to be measured in-flight in anesthtized animals by photon absorptiometry.

   C. Sample Analysis (Inflight, Postflight): Analysis by photon absorptiometry to be performed inflight. Bioassay of urine samples for pituitary gonadotropin activity to be performed post-flight.

   D. Expt. Controls (Inflight, Ground-based): Ground based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): On-board dual photon bone mineral analyzer; large primate holding and research facility.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 125-150 hours (25 hrs. for urine collections; 100 hrs. for bone mineral analysis.)

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Calcium Homeostasis CH-C

   B. Science Objectives: CH-1

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Calcium Absorption and Homeostasis in Microgravity.

2. **PURPOSE/HYPOTHESIS:** To measure gastrointestinal calcium absorption and parameters of calcium homeostasis in microgravity.Hypothesis: (a) Increased fecal calcium seen within two weeks of exposure to microgravity in primates is due to diminished calcium absorption along with increased calcium secretion; (b) These changes are independent of vitamin D3 metabolite level; (c) Fecal calcium changes are associated with an initial reduction of plasma parathormone level which reflects the primarily osseous resorptive response to microgravity.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Mature Rhesus monkeys (*M. Nemestrina* and *M. Mulatta*) are known to have calcium homeostatic processes similar to man. Evaluation of fecal calcium is required in order to determine whether or not homeostatic mechanisms are involved with initiation and maintenance of bone loss in microgravity.

4. **APPROACH:**
   A. Type/Number Specimens: Non-restrained adult male rhesus monkey; 4 animals.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Test to be performed twice during 90-day flight: Fecal samples collected in metabolic balance study and frozen for post-flight analysis. Administer Calcium-47 intravenously and simultaneously Calcium-45 by stomach tube to anesthetized animal. Quantitative collection of urine samples 0 - 24 hrs. and 24 - 48 hrs. after administration of isotope.

   C. Sample Analysis (Inflight, Postflight): Count samples inflight. Freeze plasma samples for ground-based analyses for vitamin D3 metabolites, parathyroid hormone, phosphate and calcium.

   D. Expt. Controls (Inflight, Ground-based): Ground based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Beta and gamma counters; large primate holding and research facility.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 20 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Calcium Homeostasis CH-D

B. Science Objectives: CH-1, CH-2, CH-6, CH-11, CH-18

C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Microgravity on Skeletal Growth, Maturity, and Calcium Metabolism.

2. **PURPOSE/HYPOTHESIS:** To determine bone changes which occur in rats during 1 year in flight. Hypothesis: (a) Rats, sent into space as weanlings, will show significantly less skeletal growth than their earth-bound counterparts, (b) the size, shape and number of bones in flight animals will be different from ground raised animals, (c) responses to provocative stimuli will be different in flight animals, (d) readaptation to 1 g will be more difficult with advancing age.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Gravity plays a major role in determining the size and shape of the skeletal system and is thought to be responsible for fusing many bones together during growth. Rats achieve skeletal maturity within 1 year of life. This experiment will explore the importance of gravity on growth and development of the rat skeletal system from birth to one year of age.

4. **APPROACH:**
A. Type/Number Specimens: Rats, 17-21 days old/40 (rats born inflight would be preferable if available; both F1 and F2 generations could be used).

B. Measurements/Samples (Preflight, Inflight, Postflight): Preflight: X-ray of total skeleton, body mass (if born inflight, these measurements would be made inflight). Inflight: body mass, bone markers, response to calcium load/deprivation every 90 days only on rats to be euthanized at 1 yr, and draw blood for analysis, remove bones from 5 rats every 90 days, return 5 rats to 1 g every 90 days, collect urine/feces pools weekly and preserve for analysis post-flight. Postflight: similar to inflight

C. Sample Analysis (Inflight, Postflight): Separate serum from blood and freeze. Postflight: Perform EM, histomorphometry, or biochemical analysis on bones. Analyze urine/feces.

D. Expt. Controls (Inflight, Ground-based):
Ground based controls: 20 rats, 17-21 days old.
Inflight: 1 g centrifuge controls; see flight animals for details.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Holding facility that will support rats from weanling through adulthood (80g through 600 g). Rat guillotine and surgical supplies; 1-g onboard centrifuge; x-ray machine (if animals born inflight).

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): Assumes 1) automated urine and fecal collections, 2) automated feeders and lixits. 708÷4 = 177 hours/ 90 days (includes inflight 1 g controls).

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Calcium Homeostasis CH-G

B. Science Objectives: CH-1, CH-2, CH-5, CH-6, CH-10, CH-11, CH-12, CH-18

C. McDAC Expt. Ref. #/Title (Orig. or modified): Relationship Between Bone Formation and Bone Resorption Defects in Microgravity.

2. **PURPOSE/HYPOTHESIS:** Purpose: to determine if and how the normally-coupled processes of bone formation and bone resorption are uncoupled in microgravity.Hypothesis: the known defect in osteoblast function in flight may modify the bone resorptive response in both the juvenile and adult skeletons.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Bone loss in the adult skeleton can be due to decreased formation or increased resorption or both. The known defect in osteoblast maturation or function may be accompanied by decreases in skeletal coupling factors. It is necessary to know this if appropriate countermeasures are to be developed for long term flight; the first piece of information necessary is the relationship between formation and resorption in both modeling and remodeling skeletons.

4. **APPROACH:**
A. Type/Number Specimens: Rat: N=40; 10 each at 30, 60, 90, 120 days of age. Adult Rhesus monkey (N=4); juvenile Rhesus monkey (N=4)

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: Rats: tracer injections, animal sacrifice, specimen fixation, stable calcium isotope tracer studies.
Inflight: Rats: same as preflight. Monkeys: vertebral trabecular and radius/femur cortical mineral content using high-precision computed tomography scanner at 30, 60, 90, 120 days to quantify net bone mass changes at various skeletal sites; stable calcium isotope tracer studies at 60 and 120 days to quantify whole body resorption and formation.
Postflight: Rats: same as preflight. Monkeys: tetracycline labels and bone biopsy; follow monkeys for recovery up to 1 year.

C. Sample Analysis (Inflight, Postflight):
Inflight: N/A.
Postflight:

D. Expt. Controls (Inflight, Ground-based):
Ground based controls: 1 g controls (rats and monkeys); see flight animals for details.
Inflight: 1 g centrifuge controls (rats only); see flight animals for details.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Large primate holding facility, anesthetic delivery, high-precision CT scanner, collections from large primate metabolic facility for multiple 2 weeks periods during flight.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 155 hrs (rat) + 107 hrs (monkey) for 120 days [adjusted for 90 days: 155 x .75 = 116.25 hrs. for rat; 107 x .75 = 80.25 for monkey - - 98 hours average for 90 days.]

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Calcium Homeostasis CH-H

   B. Science Objectives: CH-17, CH-18
   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Microgravity on Bone Cell Growth: Isolation of Bone Growth Factor

2. **PURPOSE/HYPOTHESIS:** Purpose: To test for differences in bone cell growth, cytoskeleton, and protein synthesis at 0 gravity, 0.5 g, 1 g, and 2 g; once differences are seen, isolate protein growth factor by 2-D gel electrophoresis.Hypothesis: Bone changes during spaceflight occur at the cellular level and can be detected in bone cell culture.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Bone cell loss is one of the most serious long term effects of spaceflight. It is possible that the bone loss due to microgravity is caused by change in metabolism at a cellular level.

4. **APPROACH:**
   A. Type/Number Specimens: 1) rat sarcoma bone cells (could be started from frozen culture). 2) primary chick bone culture.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Preflight: N/A
   Inflight: sample cultures for cell number, protein synthesis, and cytoskeletal changes. Initially, sample daily; after first week, every two days.
   Postflight: same as inflight.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: fix 5 samples in quadruplicate throughout a 4 week period.
   Postflight: analysis of above samples.

   D. Expt. Controls (Inflight, Ground-based):
   Ground-based: 1 g controls; see flight experiment for details.
   Inflight: 1 g centrifuge controls; see flight experiment for details.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): 1) Cogoli's 0 and 1 g cell incubator; 2) modify incubators for multiple sampling; 3) GPWS.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 25 hours (10 hours for the cell culture; 15 hours for the primary chick culture).

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Cardiovascular System CS-A

B. Science Objectives: CS-1

C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Cardiovascular Control in Rhesus Monkeys; I. Neuroendocrine Response with Determination of Regional Blood Flow.

2. **PURPOSE/HYPOTHESIS:** Prolonged spaceflight and microgravity increase cardiac dimensions and pressures, which in turn alter cardiac output, redistribution of blood flow to vital organs, and adrenergic control and reflex control of the cardiovascular system.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Fluid shifts are known to occur during spaceflight and microgravity. The consequent increase in cardiac dimensions and pressures will, in turn, alter cardiac output and distribution of blood flow to vital organs and will result in altered regulation of the cardiovascular system by neurohumoral reflexes of the adrenergic nervous system.

4. **APPROACH:**
A. Type/Number Specimens: 4 unrestrained adult Rhesus monkeys.

B. Measurements/Samples (Preflight, Inflight, Postflight): Monitoring twice weekly on a 90 day flight. All 4 animals should be flown on a single flight if at all possible. Microsphere injections will be administered preflight, early, mid and late inflight, and early and late postflight. Up to 12 channels of analog data with telemetry.

C. Sample Analysis (Inflight, Postflight): Blood samples collected for ground-based analysis. Periodic downlink data analysis.

D. Expt. Controls (Inflight, Ground-based): Ground-based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Large primate holding and research facility with temporary restraint system. Refrigerated centrifuge and freezer(-80°C) needed for blood samples for catecholamines, ANF, plasma renin, vasopressin, and aldosterone. Pressure transducers and sonomicrometer and telemetry system. Isotope kit, injection and withdrawal pump. Data storage system for launch.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 8.4 hours.

C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Cardiovascular System CS-B

   B. Science Objectives: CS-2

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Cardiovascular Control in Rhesus Monkeys; II. Hemodynamic Responses to Volume Changes.

2. **PURPOSE/HYPOTHESIS:** Prolonged spaceflight and microgravity increase cardiac dimensions and pressures, which in turn alter cardiac output, redistribution of blood flow to vital organs, and adrenergic control and reflex control of the cardiovascular system.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Fluid shifts are known to occur during spaceflight and microgravity. The consequent increase in cardiac dimensions and pressures will, in turn, alter cardiac output and distribution of blood flow to vital organs and will result in altered regulation of the cardiovascular system by neurohumoral reflexes of the adrenergic nervous system.

4. **APPROACH:**
   A. Type/Number Specimens: 4 unrestrained adult Rhesus monkeys.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Preflight: Measurements of cardiac output and renal, mesenteric and iliac blood flows and measurements of aortic and right ventricular oxygen, hematocrit, hemoglobin, red blood cell mass and blood volume, and electrolytes during vena caval occlusion and bilateral cartoid occlusion and volume expansion will be used to test reflex control of the circulation.
   Inflight: same.
   Postflight: same.

   C. Sample Analysis (Inflight, Postflight): Blood samples collected for ground-based analysis. Periodic downlink data analysis.

   D. Expt. Controls (Inflight, Ground-based): Ground-based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Large primate holding and research facility with temporary restraint system. Refrigerated centrifuge and freezer(-80°C) needed for blood samples for catecholamines, ANF, plasma renin, vasopressin, and aldosterone. Pressure transducers and sonomicrometer and telemetry system. Isotope kit, injection and withdrawal pump. Data storage system for launch.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 16.8 hours.

   C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Cardiovascular System CS-C

B. Science Objectives: CS-2

C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Cardiovascular Control in Rhesus Monkeys; III. Central and Regional Hemodynamic Responses to Adrenergic Stimulation and Blockade.

2. **PURPOSE/HYPOTHESIS:** Prolonged spaceflight and microgravity increase cardiac dimensions and pressures, which in turn alter cardiac output, redistribution of blood flow to vital organs, and adrenergic control and reflex control of the cardiovascular system.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Fluid shifts are known to occur during spaceflight and microgravity. The consequent increase in cardiac dimensions and pressures will, in turn, alter cardiac output and distribution of blood flow to vital organs and will result in altered regulation of the cardiovascular system by neurohumoral reflexes of the adrenergic nervous system.

4. **APPROACH:**
A. Type/Number Specimens: 4 unrestrained adult Rhesus monkeys.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: Measurements of cardiac output and regional blood flows to renal, mesenteric, and iliac circulations during administration of alpha 1, alpha 2, beta 1, beta 2 adrenergic agonists and antagonists will test the integrity of the sympathetic system. Cardiac and vascular receptors will be studied upon return to normal gravity.
Inflight: same.
Postflight: same.

C. Sample Analysis (Inflight, Postflight): Blood samples collected for ground-based analysis. Periodic downlink data analysis.

D. Expt. Controls (Inflight, Ground-based): Ground-based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Large primate holding and research facility with temporary restraint system. Refrigerated centrifuge and freezer(-80°C) needed for blood samples for catecholamines, ANF, plasma renin, vasopressin, and aldosterone. Pressure transducers and sonomicrometer and telemetry system. Isotope kit, injection and withdrawal pump. Data storage system for launch.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 16.8 hours.

C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Cardiovascular System CS-D

B. Science Objectives: CS-2

C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Cardiovascular Control in Rhesus Monkeys; IV. Cardiac and Coronary Response With and Without Chronotropic Stimulation.

2. **PURPOSE/HYPOTHESIS:** Prolonged spaceflight and microgravity increase cardiac dimensions and pressures, which in turn alter cardiac output, redistribution of blood flow to vital organs, and adrenergic control and reflex control of the cardiovascular system.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Fluid shifts are known to occur during spaceflight and microgravity. The consequent increase in cardiac dimensions and pressures will, in turn, alter cardiac output and distribution of blood flow to vital organs and will result in altered regulation of the cardiovascular system by neurohumoral reflexes of the adrenergic nervous system.

4. **APPROACH:**
A. Type/Number Specimens: 4 unrestrained adult Rhesus monkeys.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: Measurements will be made of left ventricular diameter, wall thickness and atrial dimensions and left ventricular pressure during experiments involving inferior vena caval occlusion, bilateral cartoid occlusion and volume expansion will test reflex control of the circulation and examine changes in diastolic compliance. The heart will be paced to test coronary vascular reserve.
Inflight: same.
Postflight: same.

C. Sample Analysis (Inflight, Postflight): Blood samples collected for ground-based analysis. Periodic downlink data analysis.

D. Expt. Controls (Inflight, Ground-based): Ground-based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Large primate holding and research facility with temporary restraint system. Refrigerated centrifuge and freezer(-80°C) needed for blood samples for catecholamines, ANF, plasma renin, vasopressin, and aldosterone. Pressure transducers and sonomicrometer and telemetry system. Isotope kit, injection and withdrawal pump. Data storage system for launch.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 16.8 hours.

C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Cardiovascular System CS-E

   B. Science Objectives: CS-2

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Cardiovascular Control in Rhesus Monkeys; V. Comprehensive Cardiac and Peripheral Vascular Assessment.

2. **PURPOSE/HYPOTHESIS:** Prolonged spaceflight and microgravity increase cardiac dimensions and pressures, which in turn alter cardiac output, redistribution of blood flow to vital organs, and adrenergic control and reflex control of the cardiovascular system.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Fluid shifts are known to occur during spaceflight and microgravity. The consequent increase in cardiac dimensions and pressures will, in turn, alter cardiac output and distribution of blood flow to vital organs and will result in altered regulation of the cardiovascular system by neurohumoral reflexes of the adrenergic nervous system.

4. **APPROACH:**
   A. Type/Number Specimens: 4 unrestrained adult Rhesus monkeys.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Measurements will be made of left ventricular diameter, wall thickness and atrial dimensions and left ventricular pressure during experiments administering alpha 1, alpha 2, beta 1, beta 2 adrenergic agonists and antagonists will be used to test reflex control of the sympathetic nervous system and its effects on diastolic compliance.
   Inflight: same.
   Postflight: same.

   C. Sample Analysis (Inflight, Postflight): Blood samples collected for ground-based analysis. Periodic downlink data analysis.

   D. Expt. Controls (Inflight, Ground-based): Ground-based controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Large primate holding and research facility with temporary restraint system. Refrigerated centrifuge and freezer(-80°C) needed for blood samples for catecholamines, ANF, plasma renin, vasopressin, and aldosterone. Pressure transducers and sonomicrometer and telemetry system. Isotope kit, injection and withdrawal pump. Data storage system for launch.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 16.8 hours.

   C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Endocrinology/Fluid & Electrolyte E/FE-A

   B. Science Objectives: E/FE-1, E/FE-2, E/FE-3

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Long-Term Spaceflight on Hormonal Regulation of Fluid and Electrolyte Balance in Rats

2. **PURPOSE/HYPOTHESIS:** To determine effect of long term spaceflight on the hormonal regulation of fluid and electrolyte balance in rats.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Spaceflight produces fluid/electrolyte changes in humans that cannot be explained by our present knowledge of fluid/electrolyte physiology. If rats show similar disturbances in fluid/electrolyte metabolism, then a more detailed investigation of basic mechanisms could be made.

4. **APPROACH:**
   A. Type/Number Specimens: Rats, S.D, male, 150 - 200 g - (108 rats total) 12 pre-flight; 48 flight; 48 ground controls

   B. Measurements/Samples (Preflight, Inflight, Postflight): Day 0: sacrifice 12 pre-flight for baseline data (blood electrolyte and hormone level; +2 wks, 7 day balance, sacrifice final day of study for tissue collection, 12 rats (6 zero g, 6 controls 1 g); +4 wks, 7 day balance, sacrifice on final day of study, 12 rats (6 zero g, 6 controls 1 g); +8 wks, 7 day balance, sacrifice on final day of study 12 rats (6 zero g, 6 controls 1 g); +12 wks, 7 day balance, sacrifice on final day of study, 12 rats (6 zero g, 6 controls 1 g).

   C. Sample Analysis (Inflight, Postflight):
   Inflight: measure food/water intake and urine volume during balance period.
   Postflight: analysis of blood plasma for Na+/K+, osmolarity, hormones (ADH, ANP, PRA); measure urinary electrolytes: Na+/K+ and hormones.

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: 1 g centrifuge controls
   Ground-based: controls must be housed in identical cages or RHAF.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Metabolism cages for quantitative collection of urine and feces during the 7 day balance periods (for both microgravity and 1 g flight animals).

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 145 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Immunology IM-A

   B. Science Objectives: IM-1

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Susceptibility to Bacterial and Viral Infections on Return to Earth

2. **PURPOSE/HYPOTHESIS:** To determine the effects of space flight on susceptibility to viral and bacterial infection on return to earth.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Space flight has been shown to alter components of the immune response (e.g., interferon and T-cell function). Does this have practical health-related significance in altering susceptibility to life-threatening infectious disease?

4. **APPROACH:**
   A. Type/Number Specimens: Mice: 24 per flight (12 to be infected post-flight; 12 control).

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Preflight: None
   Inflight: None
   Postflight: 1/2 mice infected with 1 LD-50 of Salmonella Typhimurium; 1/2 infected with 1 LD-50 of EMC virus immediately upon return to earth.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: none
   Postflight: survival times of infected mice determined

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: uninfected mice.
   Ground-based: infected and uninfected mice; prior determination of LD-50.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): None

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 8 1/2 hrs.

   C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Immunology IM-B

   B. Science Objectives: IM-1

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Immune Response to Vaccines

2. **PURPOSE/HYPOTHESIS:** To determine the effects of space flight on the ability to mount an immune response to commonly used vaccines.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Space flight has been shown to alter components of the immune response (e.g., interferon and T-cell function). Does this have practical health-related significance in altering immune responses to vaccines? Important in controlling resistance to life-threatening infectious disease.

4. **APPROACH:**
   A. Type/Number Specimens: Mice dedicated to the study/ 24 per flight.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Preflight: Immunize 8 animals with non-toxic tetanus toxoid, 8 with non-toxic diphtheria toxoid, 8 with killed complete Freund's adjuvant.
   Inflight: None.
   Postflight: Assess animals' immune response to antigens listed above.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: none.
   Postflight: enzyme-linked immune assays for rodents' immune response to tetanus and diphtheria toxoid, ear skin testing for response to Freund's adjuvant.

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: none.
   Ground-based: mice immunized and assessed on same basis as flight animals.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): None

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 16 hrs.

   C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Immunology IM-C

   B. Science Objectives: IM-1

   C. McDAC Expt. Ref. #/Title (Orig. or modified): Effect of Spaceflight on Immune Response; Mitogen Response of Leukocytes Postflight

2. **PURPOSE/HYPOTHESIS:** To determine if spaceflight produces a functional impairment in ability of immune respones to respond to specific challenges.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Spaceflight has been shown to alter the ability of leukocytes to respond to antigens or mitogens. In a completely controlled study, the extent and depth of these alterations will be determined.

4. **APPROACH:**
   A. Type/Number Specimens: Rodents (inbred)/ 12 per flight

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Preflight: None.
   Inflight: None.
   Postflight: Phagocytosis and blastogenesis

   C. Sample Analysis (Inflight, Postflight):
   Preflight: none.
   Inflight: none.
   Postflight: analysis of immunological function

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: none.
   Ground-based: rodents tested in same fashion as flight animals at several time intervals to establish baseline.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): None

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 8 1/2 hrs.

   C. Experiment site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Metablic Regulation: c) Cell Biology MR/CB-A

   B. Science Objectives: MR/CB-1, MR/CB-4

   C. McDAC Expt. Ref. #/Title (orig. or modified): Exocrine Function and Protein Secretion in Salivary Glands as Influenced by Microgravity

2. **PURPOSE/HYPOTHESIS:** Use of salivary glands for studying exocrine function and protein secretion . Assessing cellular ultrastructure and moleular mechanisms of action influenced by microgravity.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Measuring adaptational and homeostatic responses of beta adrenergic stimulated cellular signal processing.

4. **APPROACH:**
   A. Type/Number Specimens: Rodent salivary glands

   B. Measurements/Samples (Preflight, Inflight, Postflight): Pre-, In-, and Postflight: morphological and biochemical studies.

   C. Sample Analysis (Inflight, Postflight): Postflight: microscopy and biochemstry.

   D. Expt. Controls (Inflight, Ground-based): Groundbased and postflight recovery studies.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Liquid nitrogen fixative for electron microscopy.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 5 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Metabolic Regulation: c) Cell Biology MR/CB-C

   B. Science Objectives: MR/CB-2

   C. McDAC Expt. Ref. #/Title (orig. or modified): Mechanism of Cellular Receptor Changes Seen in Microgravity as Reflected by Associated Physiological Changes.

2. **PURPOSE/HYPOTHESIS:** Physiologic responses seen in flight can be explained at the molecular level by measuring responses of cell receptors in microgravity (eg insulin, glucocorticoids, L-DOPA, PTH, etc.) Changes in receptors will be measured in target tissues and in cell lines. Transport of small molecules will also be measured.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Data from manned space flight have shown changes in glucocortuoids, insulin response and bone and muscle metabolism. These changes could be explained by examining expression and activity of cellular receptors.

4. **APPROACH:**
   A. Type/Number Specimens: Rat and Human Target Tissue Cells - isolated cells measuring transport and receptors (cultured cell lines).

   B. Measurements/Samples (Preflight, Inflight, Postflight): Inflight: 1) Collect cell membrane for analysis of receptors after 1, 2, 4, 8, 16, 20, 30, and 40 days of flight. 2)Measure receptors and transport in cell lines at 0 and 1 g.

   C. Sample Analysis (Inflight, Postflight): In- or postflight: analyze transport and cell receptors in cell culture.

   D. Expt. Controls (Inflight, Ground-based): Groundbased parallel controls.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Micro ultra centrifuge; -70 degree freezer, GPWS; Polyiron; CO2 incubator; hardware for centrifuging and collection.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 4 hours

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Metabolic Regulation: c) Cell Biology MR/CB-D

   B. Science Objectives: MR/CB-3

   C. McDAC Expt. Ref. #/Title (orig. or modified): Energy Utilization in Eukaryotic and Prokaryotic Cells in Microgravity

2. **PURPOSE/HYPOTHESIS:** Evidence from Spacelab 1 lymphocytes and from negative nitrogen balance in astronauts would suggest an increase in full utilization in microgravity. We would like to to correlate product formation with energy utilization in cells.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Astronauts have a negative nitrogen balance in spaceflight despite a relatively high calorie intake. In addition, quiescent lymphocytes on SL-1 seemed to utilize the same energy as actively growing cells at 1 g. Both these anomalies of spaceflight could be explained by an increased energy requirement in microgravity.

4. **APPROACH:**
   A. Type/Number Specimens: 3T3 cells, lymphocytes, rat muscle cells, HeLA fibroblasts and bioengineered *e. coli* bacteria for product formation, grown at 0 and 1 g.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Inflight: take samples over a 7 day period at time of media change.

   C. Sample Analysis (Inflight, Postflight): In- or postflight: analysis of cell number (doubling time), carbon atom utilization (glucoanalysis), product formation from genetic engineered bacteria.

   D. Expt. Controls (Inflight, Ground-based): Ground controls will parallel flight.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): GPWS; coultercounter; CO2 incubator (to be developed) for 0 and 1 g; -70 freezer; glucose analyzer; cell culture plates (to be developed); cell culture plate reader.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 2 hrs 20 min

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Muscle Structure & Function MS/F-A

   B. Science Objectives: MS/F-1, MS/F-4, MS/F-9, MS/F-11

   C. McDAC Expt. Ref. #/Title (orig. or modified): Muscle Loss in Rats in Microgravity (Histology-Histochemistry)

2. **PURPOSE/HYPOTHESIS:** Histochemical analysis to determine rate of change of fiber diameter, fiber type distribution; biochemical analysis to determine the concentrations of a complex (≈10) of glycolytic-oxidative enzymes in individual muscle fibers in rat skeletal muscles (soleus, gastrocnemius, etc.)

3. **PROGRAM RATIONALE/JUSTIFICATION:** Data will provide rates at which qualitative and quantitative atrophic changes occur in the process of adaptation to microgravity and relation to load-bearing and activity. When does muscle atrophy plateau?

4. **APPROACH:**
   A. Type/Number Specimens: 24 adult male rats (300-350 g): soleus, EDL, Ant. tibialis, and gastrocnemius muscles from each.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Dissect and clamp-freeze muscles in flight. Autopsy after 0 g for 2, 4, 8, 12 weeks (4 per group) = 16 rats.

   C. Sample Analysis (Inflight, Postflight):
   Postflight: histological and histochemical analyses, single-fiber enzyme analyses (Lowry Single Fiber Method).

   D. Expt. Controls (Inflight, Ground-based):
   In-flight: rats at 1 g = 16.
   Ground-based: rats = 24. Inflight centrifuge controls: 8 rats (4 and 12 weeks; 4/group).

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Clamp-freezer; freeze-drier; animal centrifuge.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 82.1 hrs.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Muscle Structure & Function MS/F-B

   B. Science Objectives: MS/F-2, MS/F-4, MS/F-11

   C. McDAC Expt. Ref. #/Title (orig. or modified): Muscle Loss in Rats in Microgravity (Electron Microscopy/Ultrastructure)

2. **PURPOSE/HYPOTHESIS:** Ultrastructural analyses of skeletal muscle atrophy (soleus, EDL, quadriceps) removed in-flight to characterize changes in myofibrils, mitochondrial morphology and distribution, and neuromuscular junction due to space flight.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Defines in morphological terms the characteristics of muscle atrophy induced by microgravity.

4. **APPROACH:**
   A. Type/Number Specimens: 16 male adult rats. 4 groups (4 rats each) at 2, 4, 8, &12 weeks.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Inflight: fix muscles by *in vivo* perfusion, dissect and fix muscles.

   C. Sample Analysis (Inflight, Postflight):
   Post-flight: (electron microscope ground-based).

   D. Expt. Controls (Inflight, Ground-based): In-flight 1 g controls (centrifuge): 4 and 12 week exposure; 4 rats per group = 8 rats. 24 ground-based controls as above.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Animal centrifuge, *in vivo* perfusion and fixation device; implanted EMG telemetry/integrator/recorder.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 84 hrs.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

   NOTE: Specimens for this study not suitable for other experiments requiring fresh tissues since whole-body fixative perfusion is required.

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Muscle Structure & Function MS/F-C

   B. Science Objectives: MS/F-3, MS/F-5

   C. McDAC Expt. Ref. #/Title (orig. or modified): Muscle Loss in Rats in Microgravity (Electron Microscopy/Contractile Properties)

2. **PURPOSE/HYPOTHESIS:** To determine rate of change in contractile properties of slow- and fast-twitch muscles of rat hind-limb, and susceptibility to fatigue. EMG analysis of activity patterns.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Test hypothesis that slow-twitch, tonically used soleus muscle slowly transforms to muscle showing more fast-twitch contractile properties with no change in susceptibility to fatigue.

4. **APPROACH:**
   A. Type/Number Specimens: 24 male adult rats. 6 groups (4 rats each) at 0, 1, 2, 4, 8, &12 weeks.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Inflight baseline contractile properties measured *in vivo* under anaesthesia. (Contraction & relaxation times isotonic & isometric, and maximum force generation.)

   C. Sample Analysis (Inflight, Postflight): Monitor EMG activity of soleus and tibialis muscles 10 min. of every 2 hours for above weeks before sacrifice in-flight.

   D. Expt. Controls (Inflight, Ground-based): Ground-based controls as above.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Square-wave electrostimulator, force transductors and multi-channel recorders. EMG electrodes & telemetry, receiver, integrator, computer.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 60 hrs.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**

   A. Discipline/ Expt. Code: Muscle Structure &Function MS/F-D

   B. Science Objectives: MS/F-6, MS/F-7, MS/F-8, MS/F-10

   C. McDAC Expt. Ref. #/Title (orig. or modified): Muscle Loss in Rats in Microgravity (Biochemistry)

2. **PURPOSE/HYPOTHESIS:** Biochemical analyses of atrophying limb-muscles of rat.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Investigate underlying biochemical changes and mechanisms of skeletal muscle atrophy.

4. **APPROACH:**

   A. Type/Number Specimens: 6 adult male rats (300g) per group -4 groups = 24 rats total. Soleus, EDL, Gastroc, quadriceps.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Inflight: sample 6 rats at 1, 3 6, and 12 weeks.

   C. Sample Analysis (Inflight, Postflight): Postflight: hormone receptors: DNA, RNA, protein. Specific enzyme analyses: alanine cycle, translational (RNA polymerases, protein initiation factors, capping factors); 2-dimensional polyacrylamide gels; myosin isozyme electrophoresis.

   D. Expt. Controls (Inflight, Ground-based): Ground-based: 24 rats on above schedule.

5. **SPACE STATION RESOURCE REQUIREMENTS:**

   A. Special Equipment (other than common items):

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 65 hrs.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Neurosciences NS-A

   B. Science Objectives: NS-1

   C. McDAC Expt. Ref. #/Title (Orig. or Modified): Structural Changes in the Rat's Labyrinth in Microgravity.

2. **PURPOSE/HYPOTHESIS:** To determine and describe structural alterations which occur in the vestibular labyrinth during exposure to micro-gravity, and to identify their potential consequences to normal physiological function on long duration space flights.

3. **PROGRAM RATIONALE/JUSTIFICATION:** The existence of structural changes in the vestibular labyrinth and any associated physiological or performance decrements is an essential question to answer for long duration space flight. (FASEB, 1983, p. 29).

4. **APPROACH:**
   A. Type/Number Specimens: Adult rats/100 (50 experimental, 50 simulated Earth gravity controls, experiment duration 360 days).

   B. Measurements/Samples (Preflight, Inflight, Postflight): Preflight, vestibular function testing (protocols TBD) in Ames Vestibular Research Facility or equivalent; In-flight, vital signs daily; In-flight, sacrifice, dissection, and fixation of 10 experimental and 10 control animals at 90 day intervals inflight; Post-flight, sacrifice, dissection, and fixation of tissues.

   C. Sample Analysis (Inflight, Postflight): Inflight, none; postflight, Histological processing, light and electron microscopy.

   D. Expt. Controls (Inflight, Ground-based): Inflight, control animals kept at simulated Earth gravity on an on-board centrifuge.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Centrifuge capable of maintaining 50 adult rats at simulated Earth gravity in 'home cages'.

   B. Estimated Total Inflight Crew Time (Hrs/90 days, based on 1 g environment): 0.5 hr/rat/90days = 0.5x20 = 10 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Neurosciences NS-D

   B. Science Objectives: NS-1

   C. McDAC Expt. Ref. #/Title (Orig. or Modified): The Nature and Potential Consequences of Microgravity-Related Structural Changes in Central Pathways Mediating Vestibular Reflexes.

2. **PURPOSE/HYPOTHESIS:** To determine the nature and potential consequences of structural alterations in connectivity of central reflex pathways due to altered sensory inputs in micro-gravity.

3. **PROGRAM RATIONALE/JUSTIFICATION:** During the process of re-adaptation, reprogramming of sensori-motor interactions occurs. It is important to determine the structural substrates of those functional changes.

4. **APPROACH:**
   A. Type/Number Specimens: Adult rats/70

   B. Measurements/Samples (Preflight, Inflight, Postflight): Preflight, vestibular function testing (protocols TBD) in Ames Vestibular Reseach Facility or equivalent; In-flight, vital signs daily; In-flight, sacrifice, dissection and fixation of 5 experimental and 5 control specimens on days 1, 3, 10, 20, 40, and 90, with 5 experimental and 5 control animals returned to ground at end of 90 days; Post-flight, light and electron microscopy, immunocytochemistry, and TBD.

   C. Sample Analysis (Inflight, Postflight): In-flight, none; postflight, light and electron microscopy, immunocytochemistry, etc., depending on the exact experiment being performed.

   D. Expt. Controls (Inflight, Ground-based): 35 specimens in 'home cages' on Earth gravity centrifuge.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Centrifuge capable of maintaining 35 adult rats at simulated Earth gravity in 'home cages'.

   B. Estimated Total Inflight Crew Time (Hrs/90 days, based on 1 g environment): 0.5 hr/rat x 6/90 days = 3 hrs x 10 = 30 hrs + 2 hrs for return.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Neurosciences NS-I

   B. Science Objectives: NS-1, NS-4

   C. McDAC Expt. Ref. #/Title (Orig. or Modified): Recovery of Function of Gravity-Sensitive Vestibular Nerve Neurons in Earth's Gravity After Exposure to Microgravity.

2. **PURPOSE/HYPOTHESIS:** To determine the course of recovery of vestibular nerve function during readaptation to Earth's gravity.

3. **PROGRAM RATIONALE/JUSTIFICATION:** It is necessary to determine how normal function is re-established so that re-adaptation may be facilitated.

4. **APPROACH:**
   A. Type/Number Specimens: Squirrel monkey is species of choice, although others may be acceptable / probably 2 experimental specimens.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Preflight, vestibular function testing (protocols TBD) in Ames Vestibular Research Facility; In-flight, vital signs daily; post-flight, recording sessions on days 1, 3, 10, 20, 40, ... until normal function returns.

   C. Sample Analysis (Inflight, Postflight): In-flight, none; postflight, computer analysis of neural data, nature TBD by stimulus capabilities; computer analysis of neural data, nature TBD by stimulus capabilities; sacrifice for histological recovery TBD by nature of experiment.

   D. Expt. Controls (Inflight, Ground-based): None inflight; post-flight, two specimens exposed to the same stimulus and recording conditions as the experimental specimens.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): None.

   B. Estimated Total Inflight Crew Time (Hrs/90 days, based on 1 g environment): 0 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**

A. Discipline/ Expt. Code: Plant Physiology PL-A [NOTE: This experiment duplicates CELSS experiment CL-A.]

B. Science Objectives: PL-1, PL-2, PL-3 (CL-1, CL-2, CL-3)

C. McDAC Expt. Ref. #/Title (orig. or modified): Optimization of Plant Nutrient and Water Supply Systems.

2. **PURPOSE/HYPOTHESIS:** To determine the optimal method for supplying nutrients and water to plants in microgravity.

3. **PROGRAM RATIONALE/JUSTIFICATION:** This information is required to grow plants for conducting experiments in microgravity.

4. **APPROACH:**

A. Type/Number Specimens: Various plants (*Arabidopsis,* lettuce, wheat): 10 groups of 10-15 plants per group.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: none.
Inflight: environmental control for PGF, whole plants harvested at weekly intervals.
Postflight: dry weights of plant tissue.

C. Sample Analysis (Inflight, Postflight):
Inflight: environmental control for PGF.
Postflight: chemical composition of plant tissue.

D. Expt. Controls (Inflight, Ground-based): Although flight controls would not be required for all experiments, the best microgravity methods would ultimately have to be compared with a 1 g centrifuge control. Ground-based would be required for all methods tested.

5. **SPACE STATION RESOURCE REQUIREMENTS:**

A. Special Equipment (other than common items): Plant Growth Facility (PGF); freezer; 1 g centrifuge (at some point).

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 25 hrs.

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/ Expt. Code: Plant Physiology PL-B [NOTE: This experiment duplicates CELSS experiment CL-B.]

B. Science Objectives: PL-1, PL-2, PL-3 (CL-1, CL-2, CL-3)

C. McDAC Expt. Ref. #/Title (orig. or modified): Optimization of Plant Support and Orientation Mechanisms for Use in Microgravity.

2. **PURPOSE/HYPOTHESIS:** To identify the optimal methods for holding and orienting plants in microgravity.

3. **PROGRAM RATIONALE/JUSTIFICATION:** This information is required to grow plants for conducting experiments in microgravity.

4. **APPROACH:**
A. Type/Number Specimens: Various plants (*Arabidopsis,* lettuce, wheat, pine): 10 groups of 10-15 plants per group.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: none.
Inflight: environmental control for PGF, whole plants harvested at weekly intervals, videomonitoring of plant growth. Postflight: dry weights of plant tissue.

C. Sample Analysis (Inflight, Postflight):
Inflight: environmental control for PGF.
Postflight: chemical analysis of plant tissue.

D. Expt. Controls (Inflight, Ground-based):
Inflight: 1 g centrifuge control.
Ground-based: controls for all methods.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Plant Growth Facility (PGF); freezer; 1 g centrifuge; PGF videomonitor.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 35 hrs.

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Plant Physiology PL-E

   B. Science Objectives: PL-1, PL-2

   C. McDAC Expt. Ref. #/Title (orig. or modified): (A)PC1/Role of Microgravity in Control of Development at the Organ and Cellular Level.

2. **PURPOSE/HYPOTHESIS:** Higher plant development is characterized by orderly patterned and directed cell division in growing regions and meristems. To what extent will orientation of planes of division and organ formation be affected in the absence of (or perturbation of) directional influences such as hormones and physiological gradients?

3. **PROGRAM RATIONALE/JUSTIFICATION:** To understand the role of gravity in the control of development at the organ and cellular level. To understand the role of gravity in regulating metabolic and cellular processes in plants. To establish the effects of microgravity on developmental patterns.

4. **APPROACH:**
   A. Type/Number Specimens: A dicotyledonous species such as *Arabidopsis* or equivalent plant with fast life cycle; a monocotyledonous species such as oat or corn; and appropriate plant tissue cultures which can organize: 12 specimens each.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Inflight: activation or initation of development; fixation for cytological and histological sampling and cytogenic storage for postflight analysis. Videomonitor.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: gas analysis for analysis on Earth. Temporal fixation and cytogenic processing and storage at specified intervals. Analysis will be post-flight.

   D. Expt. Controls (Inflight, Ground-based): 1. a 1 g centrifuge control population will be maintained as well as : 2. a 0 g control group; 3. a 0.16 g (lunar) control group; 4. a 0.38 (Martian) control group.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Plant Growth Facility (PGF); variable g centrifuge; videomonitor; in-flight fixation; caryogenic processing and storage.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 1 hour

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/ Expt. Code: Plant Physiology PL-l

   B. Science Objectives: PL-2, PL-3

   C. McDAC Expt. Ref. #/Title (orig. or modified): Effect of Microgravity on Amyloplast Development

2. **PURPOSE/HYPOTHESIS:** Gravity perception in higher plants is achieved primarily by means of statoliths or amyloplasts in specialized cells (statocytes). We need to ascertain whether microgravity has any effect on the development and formation of amyloplasts.

3. **PROGRAM RATIONALE/JUSTIFICATION:** To understand the nature and role of gravity sensing elements in microgravity and to discover whether sensing and transduction can be uncoupled or affected at the level of the amyloplast.

4. **APPROACH:**
   A. Type/Number Specimens: Monocot such as oats or maize, dicot such as pea, *Arabidopsis:* 12 of each.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Inflight: initiate growth from seeds and prepare samples by fixation at 2-5 day intervals. Videomonitor 2-3 times each day.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: fixation for subsequent analysis.

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: 1 g centrifuge, 0 g.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Plant Growth Facility (PGF); 1 g centrifuge; videomonitor; inflight fixation apparatus.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 1 hour.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Radiobiology RA-A

   B. Science Objectives: RA-1

   C. McDAC Expt. Ref. #/Title (orig. or modified): Space Dosimetry

2. **PURPOSE/HYPOTHESIS:** Measure radiation on board space station at all animal locations.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Certain experiments may be sensitive to radiation. We need accurate information about the effects of radiation exposure (LET spectrum, HZE particle, etc.) upon these experiments. In case of solar flashes, all experiments will need radiation exposure information.

4. **APPROACH:**
   A. Type/Number Specimens: Dosimeter to be used for primates/rats/plant seeds, etc.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Passive and active dosimeters. Inflight: use passive and active dosimeters to measure radiation fields in the safe haven area of the space craft.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: read dosimeter.
   Postflight: develop passive dosimeters.

   D. Expt. Controls (Inflight, Ground-based): See C.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Passive dosimeter. Active dosimeter.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 3 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Radiobiology RA-D

B. Science Objectives: RA-2

C. McDAC Expt. Ref. #/Title (orig. or modified): Effects of Space Radiation on the Retina.

2. **PURPOSE/HYPOTHESIS:** Measure retinal damage. Extend ground-based experiments with dogs, etc.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Cosmic rays are known to penetrate the retina causing light flashes. Retinas need to be examined for radiation damage. (There is a possible comparison with terrestrial experiments on Rhesus monkeys conducted by USAF/NASA.)

4. **APPROACH:**
A. Type/Number Specimens: Primate/ collected routinely from piggyback experiments. As many different exposures as possible.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: non-invasive analysis of retinal damage.
Inflight: none.
Postflight: animals should be retained after flight at Ames Research Center. Non-invasive eye examinations on routine periodic basis.

C. Sample Analysis (Inflight, Postflight): Evaluations of retinal damage.

D. Expt. Controls (Inflight, Ground-based): All controls on which these experiments will piggyback. All animals should be kept at Ames Research Center.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Passive dosimeter; active dosimeter.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 0 hours.

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**

A. Discipline/Expt. Code: Radiobiology RA-E

B. Science Objectives: RA-2

C. McDAC Expt. Ref. #/Title (orig. or modified): Possible Cataract Formation/Hazard During Space Flight.

2. **PURPOSE/HYPOTHESIS:** Measure cataract formation in primates. Cataracts may form due to the space station radiation. Confirm & extend ground-based studies (NASA and DOD).

3. **PROGRAM RATIONALE/JUSTIFICATION:** Animals will be studied on a long-term, non-invasive basis after return to earth. The experiments will piggyback with others to achieve maximum utilization of very expensive animals. Rodents should not be used for these experiments because they are likely to give spuriously high responses. Comparison with terrestrial life-span study on Rhesus monkeys conducted by USAF/NASA.

4. **APPROACH:**

A. Type/Number Specimens: Primates. Will be done with animals used by others.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: examine animals for lenticular anomalies.
Inflight: none.
Postflight: animals should be maintained after flight at Ames Research Center. Evaluation every 3 months for as long as possible.

C. Sample Analysis (Inflight, Postflight): Grade eyes for cataract formation.
Postflight: routine examination of animals post-flight.

D. Expt. Controls (Inflight, Ground-based):
Ground-based: same number as in flight (from different piggy back experiments).

5. **SPACE STATION RESOURCE REQUIREMENTS:**

A. Special Equipment (other than common items): Active dosimeter; passive dosimeter.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 0 hours.

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Radiobiology RA-L

   B. Science Objectives: RA-2

   C. McDAC Expt. Ref. #/Title (orig. or modified): The Response of the Lungs to Cosmic Radiation

2. **PURPOSE/HYPOTHESIS:** HZE particles may induce pulmonary fibrosis and pneumonitis as does x-irradiation.

3. **PROGRAM RATIONALE/JUSTIFICATION:** A dose of 15 rem is estimated for each 90 day stay in space station. Astronauts will make multiple trips.

4. **APPROACH:**
   A. Type/Number Specimens: Mice (or rats). 20 min, 60 optimal.

   B. Measurements/Samples (Preflight, Inflight, Postflight): None.

   C. Sample Analysis (Inflight, Postflight): Inflight: none. Postflight: morphological analysis with light and electron microscopy.

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: none if 20 mice flown. 20 if 60 mice flown and if radiation shelter is on the space station.
   Ground-based: equal number to flight animals.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): None.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): Load, unload only if 20 mice. Same on centrifuge if more mice flown - 4 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Radiobology RA-K

   B. Science Objectives: RA-4

   C. McDAC Expt. Ref. #/Title (orig. or modified): Alteration in the Length and Number of Synapses in the CA-1 Area of the Hippocampus.

2. **PURPOSE/HYPOTHESIS:** To quantitatively measure the synapses in the CA-1 area of the hippocampus. The environment interaction (behavior) center is believed to be mainly located in this area. Radiation should reduce the number of synapses and affect behavior.

3. **PROGRAM RATIONALE/JUSTIFICATION:** See # 2. Ground-based studies already done to justify experiment. Radiation affects synapses and behavior.

4. **APPROACH:**
   A. Type/Number Specimens: Rats 6 animals/group. 2 groups if centrifuge on board.

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Preflight: establishment of preflight quantitation of synapses and behavior.
   Inflight: perfusion of animal prior to earth return, close to day 90.

   C. Sample Analysis (Inflight, Postflight):
   Inflight: none.
   Postflight: quantitation of changes with electron microscopy after behavior tests are complete.

   D. Expt. Controls (Inflight, Ground-based):
   Inflight: controls on centrifuge if a centrifuge available.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Electron microscope fixative.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 3.5 hrs/group
   Two groups if centrifuge on board - 7 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Radiobiology RA-I

   B. Science Objectives: RA-2

   C. McDAC Expt. Ref. #/Title (orig. or modified): Effect of Space Environment on Murine Hematopoietic Stem Cells.

2. **PURPOSE/HYPOTHESIS:** We hypothesize that the space environment produces physiologically-endochronologically-mediated stress that alters mitotic activity in proliferative tissue. The altered proliferative status changes tissue radiation sensitivity and repair capacity and will influence early and late responses to low doses of ionizing radiation.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Physiological stress in the space environment triggers regulatory systems and produces proliferative alterations in those tissues that normally undergo mitotic activity. Interactions between the space environment, proliferative status, and ionizing radiation must be evaluated, because ground-based experimentation does not consider these as issues which are expected to influence radiation risks in space. Susceptibility to or expression of late effects of radiation, *viz.* mutations, cancer and cataracts may also be influenced by proliferative status of cell populations at risk. Susceptibility to radiation injury in the hematopoietic system is expected to be influenced by the level of stem cell mitotic activity. The first step is to measure how the number of cells in mitotic cycle and cycle time are influenced by the space environment. Murine hematopoietic stem cells (CFU-S) provide a suitable and relevant model system.

4. **APPROACH:**
   A. Type/Number Specimens: 100 mice

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Pre- and Postflight: measure femur & spleen content of hematopoietic stem cells (CFU-S) & their proliferative status. Measure blood levels of various hormones (erythropoietin; ACTH, prolactin & thyroid).

   C. Sample Analysis (Inflight, Postflight): All pre- and post-flight analysis will require hormone and RIA receptor assays & standard methods will be used for measurements of CFU-S content of proliferation.

   D. Expt. Controls (Inflight, Ground-based): Only ground based needed.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): None.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 22.5 hours

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
A. Discipline/Expt. Code: Radiobiology RA-H

B. Science Objectives: RA-2

C. McDAC Expt. Ref. #/Title (orig. or modified): Effect of Space Radiation on Spermatogenisis and Intestinal Villi.

2. **PURPOSE/HYPOTHESIS:** To quantitate the response of the testes to the radiation environment on the space station and determine if post flight recovery occurs. The biological response of this system will be correlated with the on-board dosimeters. Small intestine samples will be taken from the same animals.

3. **PROGRAM RATIONALE/JUSTIFICATION:** Little is known about the long-term response to low dose cosmic radiation, especially on tissue flown in space. We have established that testes are very sensitive to less than half a rad of heavy ions. The genetic pool going into space is becoming larger and data on the reproductive system needs to be generated. Ground based studies already done to back up flight experiment. Long-term response/recovery needs to be established.

4. **APPROACH:**
A. Type/Number Specimens: Rats, male, six/group, six groups = 36 minimum.

B. Measurements/Samples (Preflight, Inflight, Postflight):
Preflight: none.
Inflight: sacrifice 6 rats each and take tissue samples at 3, 30, 60 & 90 days.
Postflight: take recovery tissue samples from remaining 12 rats on TBD schedule.

C. Sample Analysis (Inflight, Postflight):
Inflight: Removal and fixation of testes.
Postflight: As inflight and then quantitation of spermatogonial cell loss and dosimeter readings of all the tissues.

D. Expt. Controls (Inflight, Ground-based):
Inflight: If centrifuge available, then centrifuge 6 of the 12 remaining rats to remove weightlessness as a factor.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
A. Special Equipment (other than common items): Special fixative for tissues prepared for electron microscopy.

B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 30 min/sample collection & four collections in 90 days - 48 hours.

C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Radiobiology RA-G

   B. Science Objectives: RA-2

   C. McDAC Expt. Ref. #/Title (orig. or modified): Radiation Damage to Stem Cells of Skin

2. **PURPOSE/HYPOTHESIS:** There can be damage to stem cell population in the skin by high energy radiation accompanying solar flares. Animals should be returned to Space Station for second tour to determine effects of repeated exposure. We should confirm and extend current ground-based experiments with the Rhesus monkey and rabbit.

3. **PROGRAM RATIONALE/JUSTIFICATION:** HZE particles, protons, etc. can damage the stem cells & cause mutations and death. Examinations of Rhesus monkeys irradiated with protons have shown such damage in ground-based studies.

4. **APPROACH:**
   A. Type/Number Specimens: Primates. Collect as many as possible - Rhesus monkey preferred - from experiments upon which this experiment will piggyback.

   B. Measurements/Samples (Preflight, Inflight, Postflight): Pre- and postflight skin biopsies.

   C. Sample Analysis (Inflight, Postflight):
   Preflight: evaluations of skin biopsies as else from selected controls.
   Postflight: skin stem cell analysis. Dosimetry only.

   D. Expt. Controls (Inflight, Ground-based):
   Ground-based: same number as inflight; use animals from experiments on which this experiment will piggyback.
   Postflight: all animals should be maintained at Ames Research Center.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Active dosimeter; passive dosimeter.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 0 hours.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

1. **EXPERIMENT/SCIENCE OBJECTIVE REFERENCE:**
   A. Discipline/Expt. Code: Radiobiology RA-F

   B. Science Objectives: RA-2

   C. McDAC Expt. Ref. #/Title (orig. or modified): Effects of Space Radiation on Hair Follicles.

2. **PURPOSE/HYPOTHESIS:** To measure localized greying of hair due to high energy impacts with hair follicles. Based upon original experiments with high altitude balloons - see below.

3. **PROGRAM RATIONALE/JUSTIFICATION:** It is known from early balloon experiments (Haymaker, et al) that hair greying can occur thru HZE radiation. This experiment will lead to possible correlation of high energy events determined by dosimetry and hence serve as biological dosimeter.

4. **APPROACH:**
   A. Type/Number Specimens: Primates or rats (Piggyback). (Note: since hairs turn grey in these experiments, albino rats, etc. cannot be used.)

   B. Measurements/Samples (Preflight, Inflight, Postflight):
   Inflight: record HZE particles/em squared, total dose. Must be complemented by dosimetry.
   Postflight: Maintain animals at NASA Ames Research Center and conduct routine periodic examinations.

   C. Sample Analysis (Inflight, Postflight): See B.

   D. Expt. Controls (Inflight, Ground-based):
   Ground-based: same number as flight - will use controls for experiments on which this experiment will piggyback.

5. **SPACE STATION RESOURCE REQUIREMENTS:**
   A. Special Equipment (other than common items): Active dosimeter; passive dosimeter. measurements.

   B. Estimated Total Inflight Crew Time (Hrs/90 Days, based on 1 g environment): 1 hour.

   C. Experiment Site: LSRF: √ Attached Payload: Platform:

APPENDIX B

CREW REQUIREMENTS

APPENDIX B TABLE OF CONTENTS

APPENDIX B - CREW REQUIREMENTS

REFERENCE PROTOCOL GENERIC TRAINING REQUIREMENTS

NON-HUMAN REQUIREMENTS	HOURS
ANIMAL CARE AND HANDLING	40
RODENT	
PRIMATE	
OTHER	
ANIMAL HOLDING FACILITY OPERATIONS	24
WASTE MANAGEMENT	
FEED AND WATERING	
DATA COLLECTION, STORAGE, AND TRANSMISSION	
SAMPLE COLLECTION	
- BLOOD	
- URINE	
- FECES	
HARDWARE OPERATIONS AND MAINTENANCE	
WORK STATION OPERATIONS	16
SAMPLE HANDLING AND PROCESSING	40
BLOOD DRAWS AND SAMPLING HANDLING	
CATHETERIZATION	
FIXATION METHODS	
DISSECTION	
METABOLIC CAGES	
CELL CULTURE TECHNIQUES	
ISOTOPE HANDLING	
LABORATORY HARDWARE OPERATIONS	24
SMALL MASS MEASUREMENT DEVICE (SMMD)	
REFRIGERATED LAB CENTRIFUGE	
MULTI-G CENTRIFUGE	
ACTIVE/PASSIVE DOSIMETERS	
DIGITAL MICROSCOPE	
TOTAL	144 HOURS

REFERENCE PROTOCOL GENERIC TRAINING REQUIREMENTS

HUMAN REQUIREMENTS		HOURS
ISOTOPE HANDLING		8
CELL/TISSUE CULTURE TECHNIQUES		24
MICROBIOLOGICAL TECHNIQUES		24
URINE/FECES COLLECTION		24
SMS SYMPTOM RECOGNITION		16
HAZARDOUS MATERIAL HANDLING		16
GENERAL LAB HARDWARE OPERATION		
BMMD		16
MICROSCOPE TECHNIQUE		16
CENTRIFUGE		4
SMMI		4
GPWS OR EQUIVALENT		8
SCR		8
EMG/ECG SIGNAL RECOGNITION		24
	TOTAL	192

TOTAL GENERIC TRAINING: HUMAN + NON-HUMAN RQMTS 336

NOTE: AN ADDITIONAL 40 HOURS OF GENERIC TRAINING WILL BE REQUIRED FOR VENIPUNCTURE TRAINING AND BLOOD SAMPLE HANDLING.

PHASED SEQUENCE CREW HOUR REQUIREMENTS
(180 DAY SCENARIOS)
Summary - BmRP

Experiment	L-1	L-2	L-3	L-4
a	42.5	51.0	-	51.0
b	40.7	48.1	-	48.1
c	10.5	13.0	-	l3.0
d	-	137.9	-	163.0
e	67.2	83.2	-	83,2
f	67.2	-	82.3	82.3
g	48.3	-	58.5	-
h	-	-	-	-
i,j	10.5	13.0	-	13.0
k	-	160.6	189.8	-
l*	-	1216.6*	1422.0*	1422.0*
m	-	7.0	7.8	-
n	-	-	-	80.0
o	31.5	-	39.0	39.0
p	21.0	-	26.0	26.0
q	63.0	-	78.0	78.0
r	-	-	-	-
s	-	-	-	-
t	15.0	18.0	-	18.0
u1	-	-	-	-
u2	-	-	-	-
v,w	107.1	-	132.6	-
x	13.0	-	-	13.0
y,z	19.2	-	19.2	19.2
aa	-	59.4	69.8	-
ab,ac	73.5	91.0	-	91.0
ad	-	27.5	32.5	-
ah	-	123.2	145.1	-
ai,aj	16.8	-	20.8	20.8
SUBTOTAL BmRP	647.0	832.9	901.4	838.6

* Exercise, not charged to Life Sciences.

PHASED SEQUENCE CREW HOUR REQUIREMENTS
(180 Day Scenarios)
Summary - BRP

Experiment	L-1	L-2	L-3	L-4
CH-A	-	-	-	10.0
CH-B	-	-	-	125.0
CH-C	-	-	-	-
CH-D	-	177.0	-	-
CH-G	-	-	-	-
CH-H	-	25.0	-	-
CS-A	-	-	-	8.4
CS-B	-	-	-	16.8
CS-C	-	-	-	16.8
CS-D	-	-	-	16.8
CS-E	-	-	-	16.8
RA-A	3.0	-	-	-
RA-D	-	-	0	-
RA-E	-	-	0	-
RA-F	-	-	1.0	-
RA-G	-	-	0	-
RA-H	-	48.0	-	-
RA-I	22.5	-	-	-
RA-K	-	7.0	-	-
RA-L	4.0	-	-	-
IM-A	8.5	-	-	-
IM-B	16.0	-	-	-
IM-C	-	-	-	8.5
MR/CB-A	-	5.0	-	-
MR/CB-C	-	4.0	-	-
MR/CB-D	-	2.4	-	-
PL-A	-	-	25.0	-
PL-B	-	-	35.0	-
PL-E	-	-	1.0	-
PL-I	-	-	1.0	-
MS/F-A	-	-	-	82.1
MS/F-B	-	-	84.0	-
MS/F-C	-	-	-	60
MS/F-D	-	65.0	-	-
E/FE-A	-	-	-	
NS-A	-	10.0	-	-
NS-D	-	32.0	-	-
NS-I	-	-	-	0
Specimen Servicing	182.0	182.0	364.0	598
SUBTOTAL BRP	236.0	557.4	511.0	959.2

TOTALS	L1	L2	L3	L4
SUBTOTAL BRP	236.0	557.4	511.0	959.2
SUBTOTAL BmRP	647.0	832.9	901.4	838.6
HDW SVC/MAIN.	156.0	156.0	156.0	156.0
TOTAL	1039.0	1546.3	1568.4	1953.8

REFERENCE EXPERIMENT CREW REQUIREMENTS
POST L-4 - 90 DAY SCENARIO

Expt.	Crew Hours	Expt.	Crew Hours
a	111.9	CH-A	10.0
b	22.2	CH-B	125.0
c	26.0	CH-C	20.0
d	116.6	CH-D	177.0
e	41.2	CH-G	98.0
f	41.2	CH-H	25.0
g	29.3	CS-A	8.4
h	59.2	CS-B	16.8
i,j	27.7	CS-C	16.8
k	94.3	CS-D	16.8
l	711.0	CS-E	16.8
m	32.4	RA-A	3.0
n	162.0	RA-D	0.0
o	19.5	RA-E	0.0
p	13.0	RA-F	1.0
q	39.0	RA-G	0.0
r	64.8	RA-H	48.0
s	218.0	RA-I	22.5
t	32.9	RA-K	7.0
u1	40.5	RA-L	4.0
u2	13.9	IM-A	8.5
v,w	146.9	IM-B	16.0
x	6.5	IM-C	8.5
y,z	34.8	MR/CB-A	5.0
aa	34.9	MR/CB-C	4.0
ab,ac	45.5	MR/CB-D	2.4
ad	52.0	PL-A	25.0
ah	72.5	PL-B	35.0
ai,aj	30.9	PL-E	1.0
		PL-I	1.0
		MS/F-A	82.1
		MS/F-B	84.0
		MS/F-C	60.0
		MS/F-D	65.0
		E/FE-A	145.0
		NS-A	10.0
		NS-D	32.0
		NS-I	0.0
		Specimen Servicing	299.0

APPENDIX C

LAUNCH PHASE 1

APPENDIX C TABLE OF CONTENTS

PHASE 1 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chromosomal Aberration Study & Dosimetry (i,j)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EVA Work Output (ab, ac)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dysrhythmia Assessment (e)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bone Density (b)						X		X		X		X		X		X		X		X		X		X		X
Renal Stone Risk Factors (c)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Metabolic Balance For Calcium (a)							X				X				X				X				X			
Delayed Type Hypersensitivity (t)						X				X				X				X				X				
Psychosocial Support (o)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Group Interaction (p)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Problem Solving (q)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Microbial Study (ai, aj)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Drug Pharmacokinetics & Drug Monitoring (y,z)*								X		X		X		X		X		X			X			X		
Neuromuscular Activity (f)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Neuromuscular Potential Output (g)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Visual Compensation (v,w)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SMS Correlates (x)**						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Space Dosimetry (RA-A)														X	X	X	X	X	X	X	X	X	X	X	X	X
Murine Hematopoietic Stem Cells (RA-I)														X	X	X	X	X	X	X	X	X	X	X	X	X
Cosmic Radiation on Lungs (RA-L)														X	X	X	X	X	X	X	X	X	X	X	X	X
Suceptibility to Infections (IM-A)														X	X	X	X	X	X	X	X	X	X	X	X	X
Immune Response to Vaccines (IM-B)														X	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Weeks 1-5 for integration of equipment. * Samples taken 4 times a day for 3 days. ** Ad-Lib

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 1 - BmRP

Experiment	Hours
a	42.5
b	40.7
c	10.5
e	67.2
f	67.2
g	48.3
i,j	10.5
o	31.5
p	21.0
q	63.0
t	15.0
v,w	107.1
x	13.0
y,z	19.2
ab,ac	73.5
ai,aj	16.8
SUBTOTAL BmRP	647.0

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 1 - BRP

Experiment	Hours
RA-A	3.0
RA-I	22.5
RA-L	4.0
IM-A	8.5
IM-B	16.0
Specimen Servicing	182.0
SUBTOTAL - BRP	236.0
SUBTOTAL - BmRP	647.0
HARDWARE SERVICE/MAIN.	156.0
TOTAL PHASE 1	1039.0

SKILL MIX ASSESSMENT - LAUNCH 1

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS HUMAN	GENDER REQUIREMENTS ANIMAL
CALCIUM HOMEOSTASIS (a,b,c)	URINE COLLECTION SAMPLE PREP FECES COLLECTION	NONE (SKILLED)	HEALTHY NORMOTENSIVE	NO	
CARDIOVASCULAR SYSTEM (e)	ECHO SAMPLE PREP LBNP URINE COLLECTION	NONE (SKILLED)	HEALTHY, ETC. NORMOTENSIVE NON-SMOKERS ANATOMY GIVES QUANTITATIVE ECHO DATA	NO	
MUSCLE PHYSIOLOGY (f,g)	DON ACCELEROMETER DON FORCE MEAS. DEVICE	NONE (SKILLED)	HEALTHY (NO PREVIOUS HISTORY OF MUSCLE DISEASE)	NO	
RADIATION EFFECTS/ RADIOBIOLOGY (i,j)	DOSIMETER/SPECTR. MAINTENANCE	NONE (SKILLED)	HEALTHY	NO	

1

SKILL MIX ASSESSMENT - LAUNCH 1

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
BEHAVIORAL RESEARCH (o,p,q)	DATA PUNCH (COMPUTER QUEST.)	NONE (SKILLED)	NONE	NO	
IMMUNOLOGY (t) (IM-A, IM-B)	ISOTOPE INJECTION SAMPLE PREP	NONE (SKILLED)	HEALTHY	NO	
	ANIMAL CARE	NONE (SKILLED)	HEALTHY 24 MICE (IM-A) 24 MICE (IM-B)		NO
NEUROSCIENCE (v,w,x)	OCULAR NYSTAGMUS (OPERATION OF QUALITY CONTROL & DISPLAY SYSTEM)	NONE (SKILLED)	HEALTHY (NORMAL VESTIBULAR RESPONSES SUBJ. WITH EXTREME SUSCEPTIBILITY TO SPACE MOTION SICKNESS NOT ACCEPTABLE)	NO	
PHARMACOKINETICS (y, z)	URINE COLLECTION SAMPLE PREP ST'D LAB EQUIPMENT OPERATION DRUG ADM.	NONE (SKILLED)	HEALTHY	NO	
PULMONARY PHYSIO. (ab, ac)	REBR. DEVICE BMMD SAMPLE PREP ALFE OPERATION	NONE (SKILLED)	HEALTHY (NON-SMOKERS)	NO	

2

SKILL MIX ASSESSMENT - LAUNCH 1

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
MICROBIOLOGY (ai,aj)	SAMPLE COLLECTION PHOTOMICROGRAPH OPERATION INCUBATOR OPERATION	NONE (SKILLED)	NONE	NO	
RADIATION EFFECTS (RA-A,RA-I,RA-L)	READ DOSIMETER RECORD ANIMAL SURGERY TISSUE COLLECTION TISSUE FIXATION HORMONE ASSAYS RIA ASSAY SPLEEN COLONY ASSAY PERFUSION OF RATS	NONE (SKILLED)	HEALTHY 100 MICE (RA-L) 20mm, 60 OPT RATS OR MICE (RA-L)		NO

PHASED SEQUENCE TRAINING REQUIREMENTS: L-1

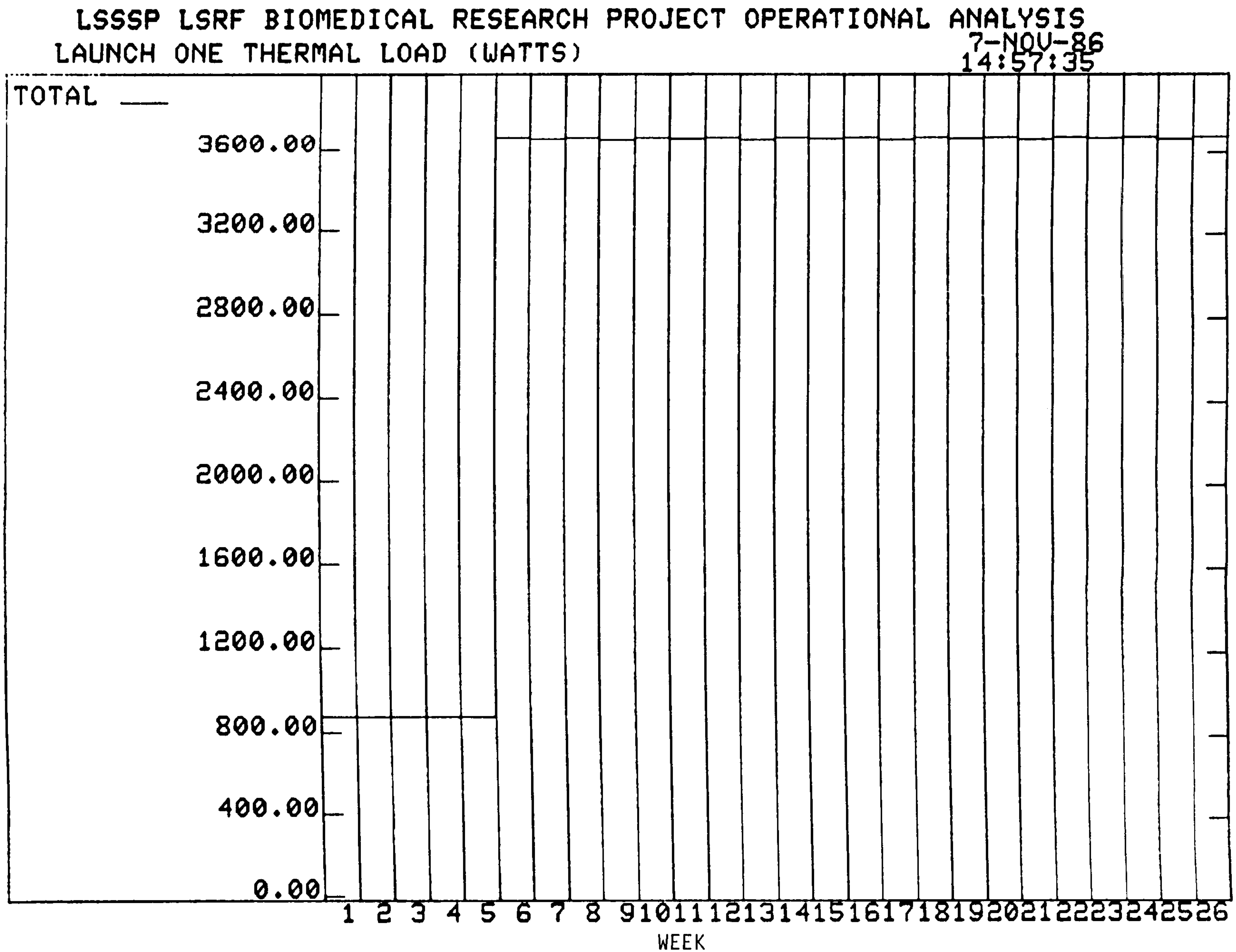
DISCIPLINE / NAME	OPERATOR	SUBJECT
CALCIUM HOMEOSTASIS		
METABOLIC BALANCE FOR CALCIUM AND OTHER BONE RELATED CONSTITUENTS (a)	16	16
BONE DENSITY MEASUREMENTS (b)	20	8
MEASUREMENTS OF RENAL STONE RISK FACTORS (c)	8	8
CARDIOVASCULAR		
DYSRHYTHMIA ASSESSMENT (e)	24	8
MUSCLE PHYSIOLOGY		
MEASUREMENT OF INFLIGHT NEUROMUSCULAR ACTIVITY (f)	30	15
NEUROMUSCULAR POTENTIAL OUTPUT DURING SPACEFLIGHT (g)	32	16
RADIOBIOLOGY		
CHROMOSOMAL ABERRATION STUDY AND DOSIMETRY FOR ALL LIFE SCIENCES SUBJECTS (i,j)	8	4
SPACE DOSIMETRY (RA-A)	4	-
EFFECT OF SPACE ENVIRONMENT OF MURINE HEMATOPOIETIC STEM CELLS (RA-I)	-	-
THE RESPONSE OF THE LUNGS TO COSMIC RADIATION (RA-L)	-	-

PHASED SEQUENCE TRAINING REQUIREMENTS: L-1

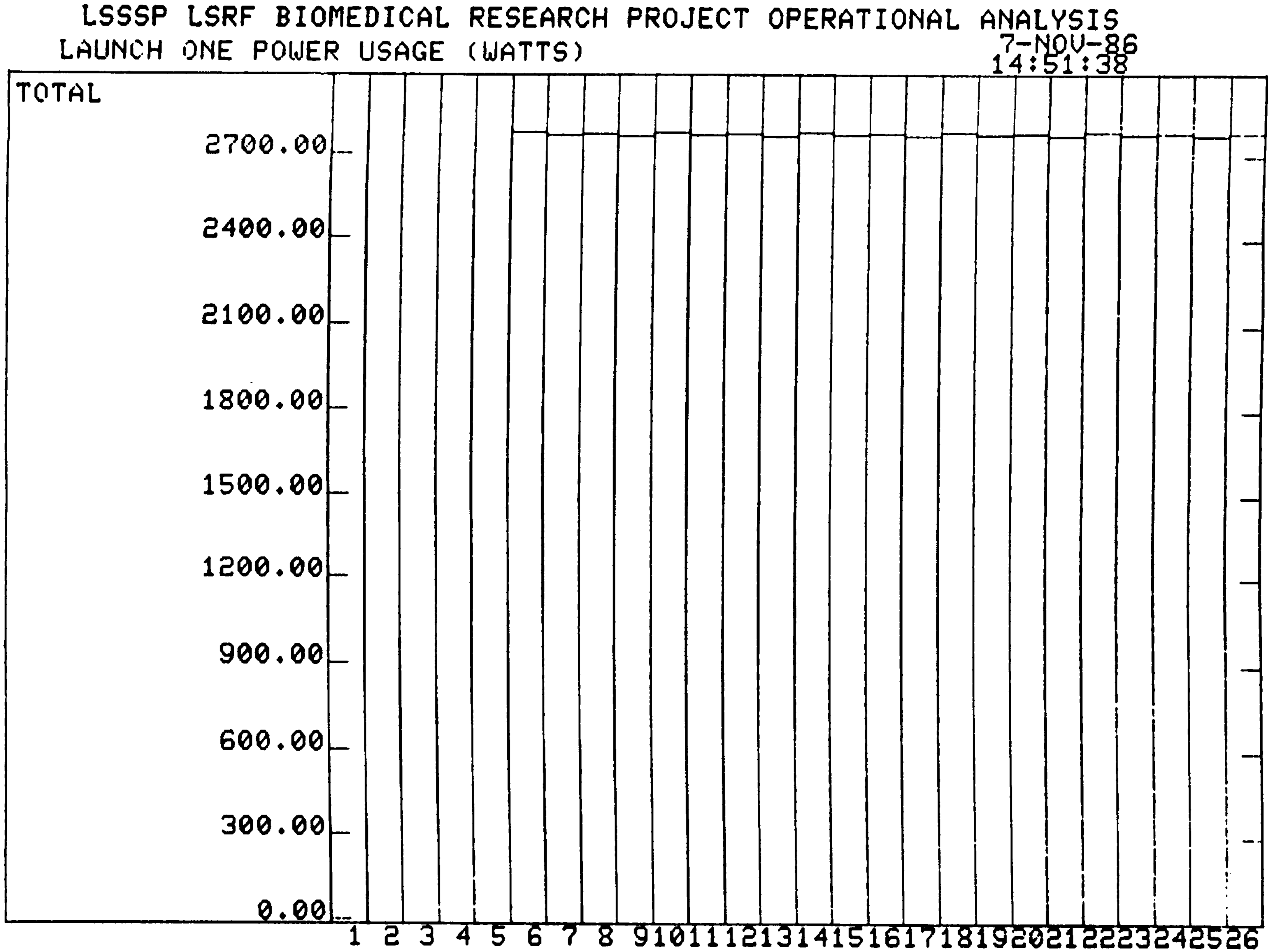
DISCIPLINE	NAME	OPERATOR	SUBJECT
BEHAVIORAL RESEARCH			
	THE EFFECTIVENESS OF INDIVIDUALLY TAILORED PSYCHOSOCIAL SUPPORT METHODS IN ACTUAL SPACEFLIGHT SETTINGS (o)	8	-
	GROUP INTERACTION, COMPATIBILITY, AND EFFECTIVENESS (p)	8	-
	PROBLEM SOLVING (q)	16	-
IMMUNOLOGY			
	DELAYED TYPE HYPERSENSITIVITY (t)	12	4
	EFFECT OF SPACEFLIGHT ON SUSCEPTIBILITY TO BACTERIAL AND VIRAL INFECTIONS ON RETURN TO EARTH (IM-A)	-	-
	EFFECT OF SPACEFLIGHT ON IMMUNE RESPONSE TO VACCINES (IM-B)	-	-
NEUROSCIENCE			
	VESTIBULO-VISUAL AND CANALICULAR-OTOLITH COMPENSATION (v,w)	40	20
	SMS CORRELATES (x)	8	-
PHARMACOKINETICS			
	DRUG PHARMACOKINETICS IN SPACE AND EVALUATION OF MODERN NON-INVASIVE METHODS FOR CLINICAL DRUG MONITORING (y,z)	16	8

PHASED SEQUENCE TRAINING REQUIREMENTS: L-1

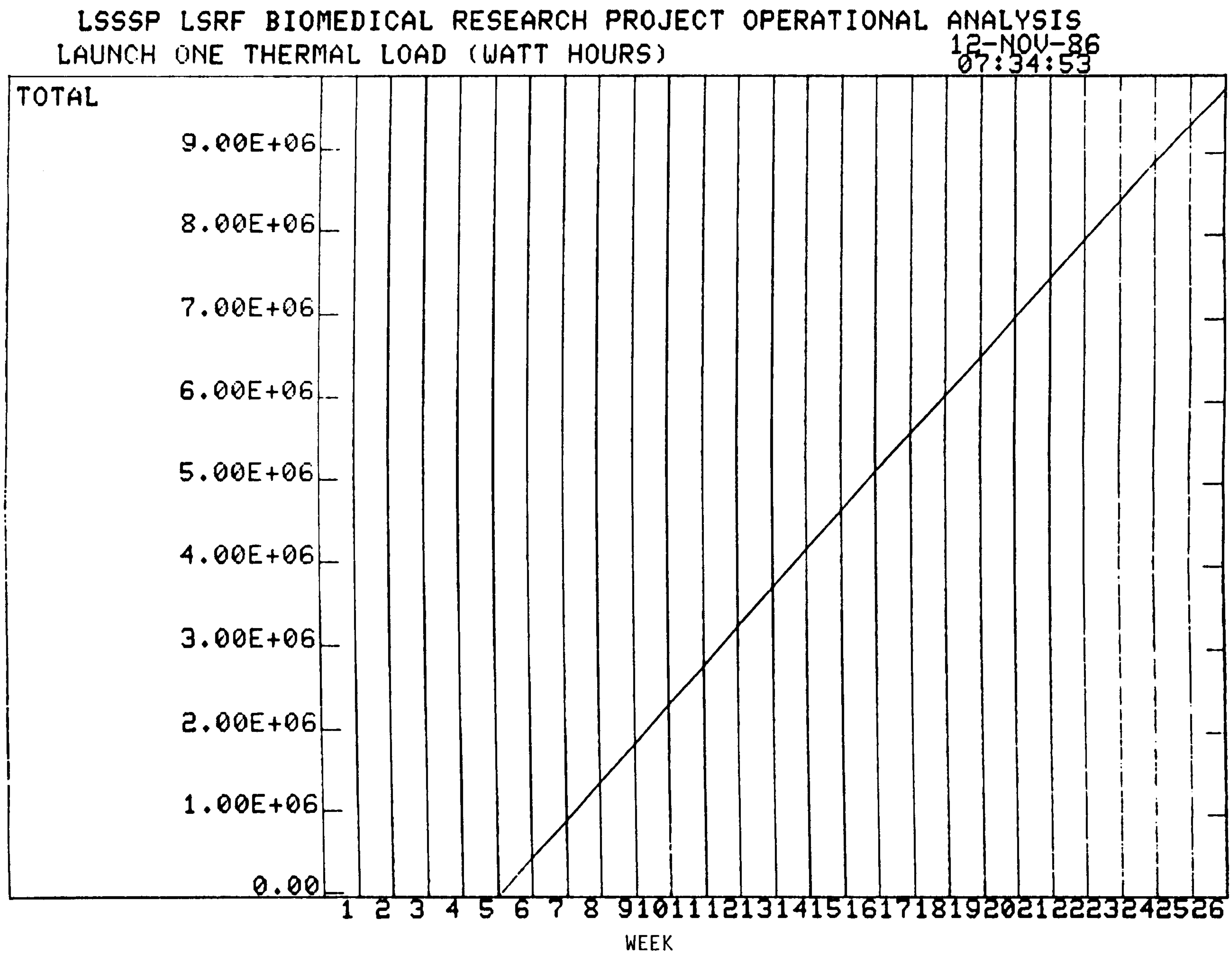
DISCIPLINE / NAME	OPERATOR	SUBJECT
PULMONARY PHYSIOLOGY		
EVALUATE EVA WORK OUTPUT AND CARDIOVASCULAR RESPONSE (ab,ac)	24	16
MICROBIOLOGY		
CREWMEMBER AND SPACE STATION MICROBIAL STUDY (ai,aj)	16	8
TOTAL TASK	290	131
TOTAL GENERIC	192	0
TOTAL PHASE/INTEGRATED	80	0
TOTAL L-1 TRAINING HOURS	562	131



Thermal Load Profile for Launch 1

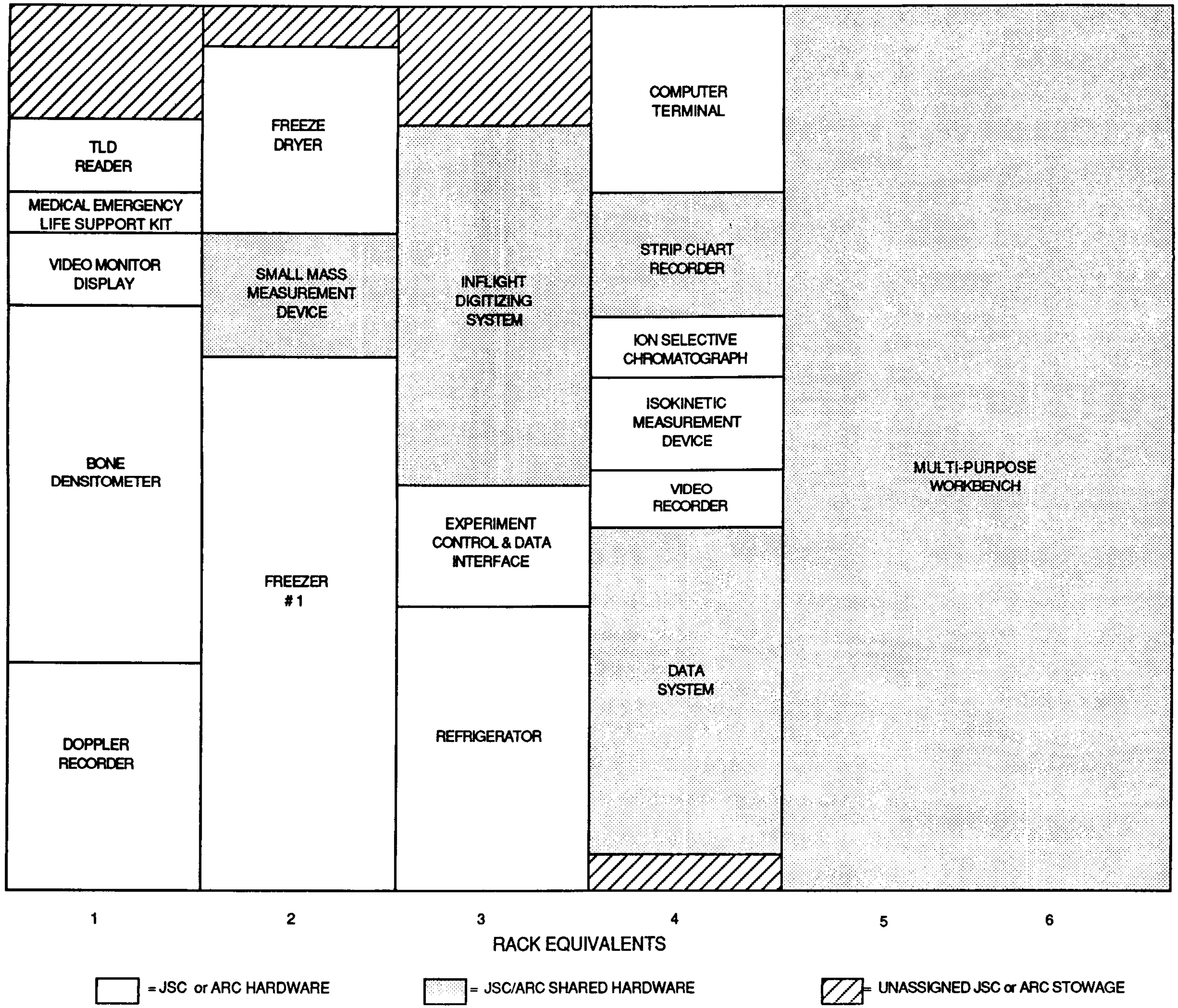


Power Profile for Launch 1



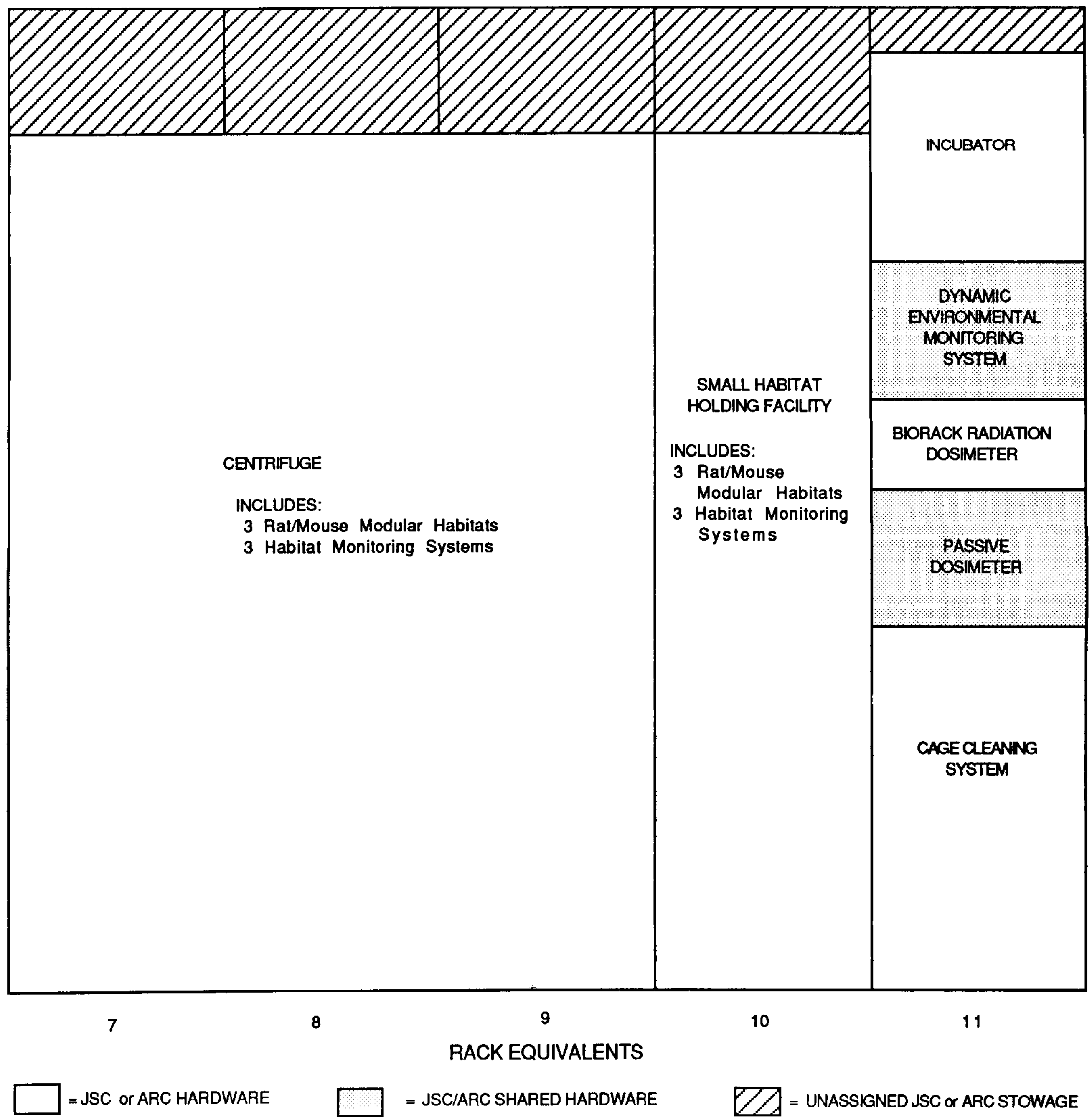
ENERGY PROFILE FOR LAUNCH ONE

PHASE 1



TLD READER
MEDICAL EMERGENCY LIFE SUPPORT KIT
VIDEO MONITOR DISPLAY
BONE DENSITOMETER
DOPPLER RECORDER
FREEZE DRYER
SMALL MASS MEASUREMENT DEVICE
FREEZER #1
INFLIGHT DIGITIZING SYSTEM
EXPERIMENT CONTROL & DATA INTERFACE
REFRIGERATOR
COMPUTER TERMINAL
STRIP CHART RECORDER
ION SELECTIVE CHROMATOGRAPH
ISOKINETIC MEASUREMENT DEVICE
VIDEO RECORDER
DATA SYSTEM
MULTI-PURPOSE WORKBENCH
1
2
3
4
5
6
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

PHASE 1



INCUBATOR
DYNAMIC ENVIRONMENTAL MONITORING SYSTEM
BIORACK RADIATION DOSIMETER
PASSIVE DOSIMETER
CAGE CLEANING SYSTEM
SMALL HABITAT HOLDING FACILITY
INCLUDES:
3 Rat/Mouse Modular Habitats
3 Habitat Monitoring Systems
CENTRIFUGE
INCLUDES:
3 Rat/Mouse Modular Habitats
3 Habitat Monitoring Systems
7
8
9
10
11
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

		PAYLOAD TOTALS			ITEM CHARACTERISTICS						
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
1	Biorack Radiation Dosimeter	1	0.008	5.00	0	0.200	0.200	0.200	5.00		
2	Cage Cleaning System	1	0.320	100.00	500	0.800	0.500	0.800	100.00	500	
3	Centrifuge -- 1-G Control (6 ft dia)	1	4.500	1000.00	200				1000.00	200	See note at bottom of this page.
4	Data System	1	0.320	40.00	200	0.800	0.500	0.800	40.00	200	
5	Densitometer, Bone	1	0.257	136.08	300	0.599	0.483	0.889	136.08	300	
6	Display, Video Monitor	1	0.029	6.80	50	0.660	0.483	0.090	6.80	50	
7	Dosimeter, Passive, Operator	1	0.090	5.00	0	0.600	0.500	0.300	5.00	0	
8	Dynamic Environl Meas. System	1	0.075	40.00	20	0.500	0.500	0.300	40.00	20	
9	Freeze Dryer	1	0.067	19.34	140	0.483	0.305	0.457	19.34	140	
10	Freezer #1	1	0.365	19.34	200	0.610	0.450	1.331	19.34	200	
11	Habitat Monitoring System	3	0.000	60.00	75	0.660	0.406	0.356	20.00	25	Included in Holding Facility
12	Habitat Monitoring System	3	0.000	60.00	75	0.660	0.406	0.356	20.00	25	Included in Holding Facility
13	Incubator	1	0.142	27.22	100	0.632	0.483	0.464	27.22	100	
14	Inflight Digitizing System	1	0.120	35.00	500	0.600	0.500	0.400	35.00	500	
15	Ion Selective Chromotograph	1	0.024	12.69	200	0.495	0.146	0.330	12.69	200	
16	Isokinetic Measurement Device	1	0.017	7.98	0	0.305	0.254	0.222	7.98	0	
17	Life Support Kit, Med Emergency	1	0.026	13.61	100	0.610	0.483	0.089	13.61	100	
18	Mass Meas. Device, Small	1	0.075	15.00	15	0.500	0.500	0.300	15.00	15	
19	Multi purpose work bench	1	1.920	350.00	500	0.800	1.000	2.400	350.00	500	
20	Rat/Mouse Modular Habitat (0.1 cu m)	3	0.000	90.00	150	0.660	0.406	0.356	30.00	50	Included in Holding Facility
21	Rat/Mouse Modular Habitat (0.1 cu m)	3	0.095	90.00	150	0.660	0.406	0.356	30.00	50	
22	Reader T L D	1	0.023	15.42	150	0.508	0.254	0.181	15.42	150	
23	Recorder, Doppler	1	0.137	9.53	50	0.508	0.483	0.559	9.53	50	
24	Recorder, Video	1	0.037	15.42	75	0.508	0.483	0.152	15.42	75	
25	Refrigerator (4°C)	1	0.171	34.93	200	0.574	0.424	0.701	34.93	200	
26	SCR, Multichannel	1	0.090	30.00	150	0.600	0.500	0.300	30.00	150	
27	Small Habitat Holding Facility	1	0.750	150.00	250				150.00	250	
28	Terminal, Computer	1	0.112	9.07	100	0.508	0.483	0.457	9.07	100	
29	Video System	4	0.600	180.00	600	0.600	0.500	0.500	45.00	150	
30											
31											
32	TOTALS FOR RACK MOUNTED EQUIPMENT		10.372	2577.43	5050						
33											
34	NOTE: The 6 ft dia centrifuge (line										
35	item 3 above) has a peak power										
36	of 1000W at startup.										
37											
38											

		PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	••••••	•••••••	••••••••	••••••	••••••	••••••	•••••••	••••••	•••••••••••••••••••••••••••••••••••
1	Accelerometer and Recorder	1	0.025	16.06	35	0.356	0.483	0.143	16.06	35	
2	Agar Strips	754	0.036	1.00	0	0.025	0.076	0.025	0.00	0	
3	Amplifier	6	0.004	0.50	28	0.025	0.229	0.102	0.08	28	
4	Antigen Kit	1	0.001	0.53	0	0.051	0.102	0.127	0.53	0	
5	Calorimeter	6	0.154	330.00	0	0.279	0.279	0.330	55.00	0	
6	Camera, Video	1	0.003	2.00	50	0.305	0.076	0.114	2.00	50	
7	Dosimeter, Microdosimetric	1	0.015	54.43	0	0.076	0.483	0.400	54.43	0	
8	Drug Consumables Kit	1	0.002	2.00	0	0.102	0.102	0.152	2.00	0	
9	E M G, Surface	1	0.016	18.14	20	0.514	0.483	0.063	18.14	20	
10	Electrode Kit, E M G	312	0.029	21.04	0	0.203	0.076	0.006	0.07	0	
11	Electrode Kit, ECG	234	0.022	15.78	0	0.203	0.076	0.006	0.07	0	
12	Electrode Kit, EOG	78	0.007	5.90	0	0.203	0.076	0.006	0.08	0	
13	Electromagnetic Tendon Striker	1	0.001	0.53	0	0.102	0.152	0.064	0.53	0	
14	Feces Collection System, 24 Hr	1	0.120	18.14	50	0.495	0.508	0.476	18.14	50	
15	Force Measurement Device	1	0.028	0.45	10	0.305	0.305	0.305	0.45	10	
16	Force Resistance System	1	0.002	1.04	0	0.200	0.200	0.050	1.04	0	
17	Goniometer and Recorder	1	0.002	1.81	25	0.102	0.102	0.152	1.81	25	
18	Mass Measure Calibration Kit	1	0.002	2.00	0	0.200	0.100	0.100	2.00	0	
19	Meter, Electrode Impedance	1	0.001	0.59	0	0.155	0.104	0.053	0.59	0	
20	Microphone	1	0.001	0.27	10	0.051	0.013	0.013	0.27	10	
21	Optokinetic Stimulus	1	0.033	17.45	0	0.261	0.483	0.261	17.45		
22	Oscilloscope, Mini Recording	1	0.004	2.27	0	0.305	0.152	0.076	2.27	0	
23	Osometer	1	0.017	5.44	20	0.254	0.356	0.185	5.44	20	
24	Paper, S C R, Multichannel	32	0.245	57.60	0	0.330	0.152	0.152	1.80	0	
25	Physiol Hemodynamic Assessment Dev	1	0.071	0.53	100	0.482	0.482	0.304	0.53	100	
26	Reuter Microbiology Air Sampler	1	0.005	1.45	50	0.203	0.152	0.152	1.45	50	
27	Saliva Collection Unit	288	0.014	6.53	0	0.025	0.025	0.076	0.02	0	
28	Signal Conditioner, E O G	1	0.000	0.05	20	0.015	0.038	0.048	0.05	20	
29	Slide Preparation Kit, Urine	1	0.000	0.73	0	0.152	0.076	0.032	0.73	0	
30	Spectrometer,Proton/Heavy Ion	1	0.008	9.07	100	0.127	0.483	0.133	9.07	100	
31	Subject Restraint System	1	0.004	11.34	0	0.152	0.152	0.152	11.34	0	
32	T L D	6	0.001	0.16	0	0.076	0.051	0.006	0.03	0	
33	Urine Collection System, 24 Hr	1	0.138	18.14	50	0.566	0.476	0.513	18.14	50	
34	Vials, Feces Sample	2160	0.026	122.26	0	0.013	0.013	0.076	0.06	0	
35	Vials, Feces Sample, Spare	216	0.003	12.22	0	0.013	0.013	0.076	0.06	0	
36	Vials, Urine Sample	2160	0.026	122.26	0	0.013	0.013	0.076	0.06	0	
37	Vials, Urine Sample, Spare	216	0.003	12.22	0	0.013	0.013	0.076	0.06	0	
38	Video Cassettes, Box of 20	5	0.188	25.00	0	0.500	0.500	0.150	5.00	0	
39	Voice Recorder	6	0.002	3.17	0	0.028	0.075	0.125	0.53	0	
40	Voice Recorder Cassettes	20	0.001	20.00	0	0.005	0.035	0.008	1.00	0	
41	Wipes, Dry, Box	21	0.016	2.10	0	0.150	0.100	0.050	0.10	0	
42	Wipes, Wet, Box	21	0.032	2.10	0	0.150	0.100	0.100	0.10	0	
43	Worktop	1	0.007	0.53	0	0.030	0.483	0.508	0.53	0	
44	TOTALS FOR STOWED ITEMS		1.5712	944.83	568						

		PAYLOAD TOTALS			ITEM CHARACTERISTICS						
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••••
1	Agar Strips	754	0.036	0.75	0	0.025	0.076	0.025	0.00	0	
2	Drug Consumables Kit	1	0.002	2.00	0	0.102	0.102	0.152	2.00	0	
3	Electrode Kit, E M G	312	0.029	21.04	0	0.203	0.076	0.006	0.07	0	
4	Electrode Kit, ECG	234	0.022	15.78	0	0.203	0.076	0.006	0.07	0	
5	Paper, S C R, Multichannel	32	0.245	57.60	0	0.330	0.152	0.152	1.80	0	
6	Rat/Mouse Modular Habitat (0.1 cu m)	9	0.859	270.00	300	0.660	0.406	0.356	30.00	50	
7	Saliva Collection Unit	288	0.014	6.53	0	0.025	0.025	0.076	0.02	0	
8	Slide Preparation Kit, Urine	1	0.000	0.73	0	0.152	0.076	0.032	0.73	0	
9	Specimens (Rats)	36	0.000	18.00	0				0.50	0	In Habitat Modules
10	T L D	6	0.001	0.16	0	0.076	0.051	0.006	0.03	0	
11	Vials, Feces Sample	2160	0.026	122.26	0	0.013	0.013	0.076	0.06	0	
12	Vials, Urine Sample	2160	0.026	122.26	0	0.013	0.013	0.076	0.06	0	
13	Video Cassettes, Box of 20	5	0.188	25.00	0	0.500	0.500	0.150	5.00	0	
14	Voice Recorder Cassettes		0.001	0.00		0.055	0.035	0.008	0.53	0	
15	Wipes, Dry, Box	21	0.016	2.10	0	0.150	0.100	0.050	0.10	0	
16	Wipes, Wet, Box	21	0.032	2.10	0	0.150	0.100	0.100	0.10	0	
17	Failed Hardware Replacements (10%)		1.1869	352.23							
18	Hardware For Changeout (2.5%)		0.2967	88.056							
19											
20											
21	TOTALS FOR RESUPPLY ITEMS		3.278	1106.6	300						
22											
23											

ORIGINAL PAGE IS
OF POOR QUALITY

LAUNCH 1-A RETURN - REFERENCE MISSION OPERATIONAL ANALYSIS DOCUMENT

		PAYLOAD TOTALS			ITEM CHARACTERISTICS						
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••	•••••	•••••••	••••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••
1	Rat/Mouse Modular Habitat (empty)	6	0.095	180.00	0	0.660	0.406	0.356	30.00	0	
2	Waste, Solid		3.589	883.4							
3	Waste, Liquid		0.423	1024.13							
4	Samples, Frozen		0.0019	0.0017							
5	Samples, Ambient or Refrigerated		0.0029	0.0026							
6	Failed Hardware (10%)		1.1943	352.23							
7	Hardware From Changeout (2.5%)		0.2986	88.056							
8											
9											
10	TOTAL LAUNCH 1A RETURN		5.5094	2347.8							
11											
12											

APPENDIX D

LAUNCH PHASE 2

APPENDIX D TABLE OF CONTENTS

PHASE 2 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Metabolic Balance for Calcium (a)	X				X				X				X				X				X					
Bone Density (b)		X		X		X		X		X		X		X		X		X		X		X		X		X
Renal Stone Risk Factors (c)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hemodynamic Alterations (d)					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dysrhythmia Assessment (e)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chromosomal Aberration Study & Dosimetry (i,j)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Muscle Adaptation & Readaptation (k)					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Exercise Program (l) *					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Venous Pressure & Plasma Volume (m) **					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Delayed Type Hypersensitivity (t)	X				X				X					X				X				X				
Inert Gas Exchange (aa)					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EVA Work Output (ab,ac)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EVA Bubble Information (ad)					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pulmonary Function (ah) ***					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Skeletal Growth (CH-D)	X	X	X	X	X	X	X	X	X	X	X	X	X													
Bone Cell Growth (CH-H)														X	X	X	X	X	X	X	X	X	X	X	X	X
Radiation on Sperm & Intestinal Cells (RA-H)														X		X				X				X		
Alterations of Synapses in the Hippocampus (RA-K)																										X
Salivary Glands (MR/CB-A)														X	X	X	X	X	X	X	X	X	X	X	X	X
Cellular Receptor Changes (MR/CB-C)														X	X	X	X	X								
Energy Utilization in Cells (MR/CB-D)						X																				
Muscle Loss in Rats IV (MS/F-D)															X		X			X						X

NOTES: Weeks 1-4 for integration of equipment. * Exercise Performed Daily, not charged to Life Sciences ** See Protocol *** Calibration Performed Daily

**** Ad-lib

PHASE 2 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Changes in Rats Labyrinth (NS-A)	X	X	X	X	X	X	X	X	X	X	X	X	X													
Structural Changes in Vestibular Reflexes (NS-D)														X	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Weeks 1-4 for integration of equipment. * Exercise Performed Daily, not to be charged to Life Sciences ** See Protocol *** Calibration Performed Daily
**** Ad-lib

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 2 - BmRP

Experiment	Hours
a	51.0
b	48.1
c	13.0
d	137.9
e	83.2
k	160.6
i,j	13.0
l*	1216.6
m	7.0
t	18.0
aa	59.4
ab,ac	91.0
ad	27.5
ah	123.2
Subtotal BmRP	832.9

* Exercise, not charged to Life Sciences

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 2 - BRP

Experiment	Hours
CH-D	177.0
CH-H	25.0
RA-H	48.0
RA-K	7.0
MR/CB-A	5.0
MR/CB-C	4.0
MR/CB-D	2.4
MS/F-D	65.0
NS-A	10.0
NS-D	32.0
Specimen Servicing	182.0
SUBTOTAL - BRP	557.4
SUBTOTAL - BmRP	832.9
HARDWARE SERVICE/MAIN.	156.0
TOTAL PHASE 2	1546.3

SKILL MIX ASSESSMENT - LAUNCH 2

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
CALCIUM HOMEOSTASIS (a,b,c)	URINE COLLECTION SAMPLE PREP FECES COLLECTION	NONE (SKILLED)	HEALTHY NORMOTENSIVE	NO	
CARDIOVASCULAR SYSTEM (d)	ECHO BLOOD COLLECTION SAMPLE PREP LBNP URINE COLLECTION	NONE (SKILLED)	HEALTHY, ETC. NORMOTENSIVE NON-SMOKERS ANATOMY GIVES QUANTITATIVE ECHO DATA	NO	
CARDIOVASCULAR SYSTEM (e)	ECHO SAMPLE PREP LBNP URINE COLLECTION	NONE (SKILLED)	HEALTHY, ETC. NORMOTENSIVE NON-SMOKERS ANATOMY GIVES QUANTITATIVE ECHO DATA	NO	
RADIATION EFFECTS/ RADIOBIOLOGY (i,j)	DOSIMETER/SPECTR. MAINTENANCE	NONE (SKILLED)	HEALTHY	NO	
EXERCISE PHYSIOLOGY (k,l)	PERFORM ISOKINETIC EXERCISE PERFORM AEROBIC EXERCISE PERFORM ANAEROBIC EXERCISE	NONE (SKILLED)	HEALTHY	NO	

SKILL MIX ASSESSMENT - LAUNCH 2

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
ENDOCRINOLOGY/ FLUID ELECTROLYTES (m)	URINE COLLECTION SAMPLE PREP VENOUS PRES.	NONE (SKILLED)	HEALTHY	NO	
IMMUNOLOGY (t)	ISOTOPE INJECTION SAMPLE PREP	NONE (SKILLED)	HEALTHY	NO	
PULMONARY PHYSIOLOGY (aa,ab,ac,ad,ah)	REBR. DEVICE BMMD SAMPLE PREP ALFE OPERATION	NONE (SKILLED)	HEALTHY (NON-SMOKERS)	NO	
CALCIUM HOMEOSTASIS (CH-D,CH-H)	ANIMAL SURGERY TISSUE COLLECTION URINE COLLECTION FECAL COLLECTION ISOTOPE INJECTION BLOOD COLLECTION URINE ANALYSIS BLOOD ANALYSIS BETA & GAMMA COUNTER OPERAT. BODY MEASUREMENT TOMOGRAPHY SCANNER CELL CULTURE 2-D GEL ELECTRO-PHORESIS	NONE (SKILLED)	ADULT RHESUS MONKEY JUVENILE RHESUS MON. RATS 17-21 DAYS OLD RATS 30,60,90,120 DAYS OLD		YES ADULT MALE MONKEY

SKILL MIX ASSESSMENT - LAUNCH 2

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
NEUROSCIENCE (NS-A, NS-D)	SMALL ANIMAL SURG. TISSUE COLLECTION FIXATION	NONE (SKILLED)	100 RATS (A) 70 RATS (D)		NO
RADIATION EFFECTS (RA-H, RA-K)	READ DOSIMETER RECORD ANIMAL SURGERY TISSUE COLLECTION TISSUE FIXATION HORMONE ASSAYS RIA ASSAY SPLEEN COLONY ASSAY PERFUSION OF RATS	NONE (SKILLED)	HEALTHY 12 RATS (RA-K) 36 RATS (RA-H)		NO
METABOLIC REGULATION (MR/CB-A,MR/CB-C MR/CB-D)	BIOCHEMICAL ASSAY EM FIXATION ISOLATION OF CELL MEMBRANES MEASURE RECEPTOR & TRANSPORT CELL LINES CELL CULTURE CLUCOANALYSIS CEU COUNTING BY-PRODUCT ANALYSIS	NONE (SKILLED)	N/A		NO

SKILL MIX ASSESSMENT - LAUNCH 2

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
MUSCLE STRUCTURE & FUNCTION (MS/F-D)	SMALL ANIMAL SURG. CLAMP-FREEZE TISSUE TISSUE FIXATION BIOCHEMICAL ANALY. OF TISSUE MEASURE CONTRACTIL PROPERTIES MONITOR EMG ACTIV.	NONE (SKILLED)	24 RATS (D)		YES ADULT MALE RATS

PHASED SEQUENCE TRAINING REQUIREMENTS: L-2

DISCIPLINE	NAME	OPERATOR	SUBJECT
CALCIUM HOMEOSTASIS			
	METABOLIC BALANCE FOR CALCIUM AND OTHER BONE RELATED CONSTITUENTS (a)	16	16
	BONE DENSITY MEASUREMENTS (b)	20	8
	MEASUREMENTS OF RENAL STONE RISK FACTORS (c)	8	8
	EFFECT OF MICROGRAVITY ON SKELETAL GROWTH, MATURITY, AND CALCIUM METABOLISM (CH-D)	36	-
	EFFECT OF MICROGRAVITY ON BONE CELL GROWTH: ISOLATION OF BONE GROWTH FACTOR (CH-H)	12	-
CARDIOVASCULAR			
	FULL ASSESSMENT OF HEMODYNAMIC ALTERATIONS	40	16
	DYSRHYTHMIA ASSESSMENT (e)	24	8
RABIOBIOLOGY			
	CHROMOSOMAL ABERRATION STUDY AND DOSIMETRY FOR ALL LIFE SCIENCES SUBJECTS (i, j)	8	4
	EFFECT OF SPACE RADIATION ON SPERMATOGENESIS AND INTESTINAL VILLI (RA-H)	28	-
	ALTERATION IN THE LENGTH AND NUMBER OF SYNAPSES IN THE CA-1 AREA OF THE HIPPOCAMPUS (RA-K)	16	-
EXERCISE PHYSIOLOGY			
	MUSCLE ADAPTATION AND READAPTATION (MUSCLE PERFORMANCE CHANGES) (k)	8	16
	EXERCISE PROGRAM FOR SPACEFLIGHT (l)	8	8

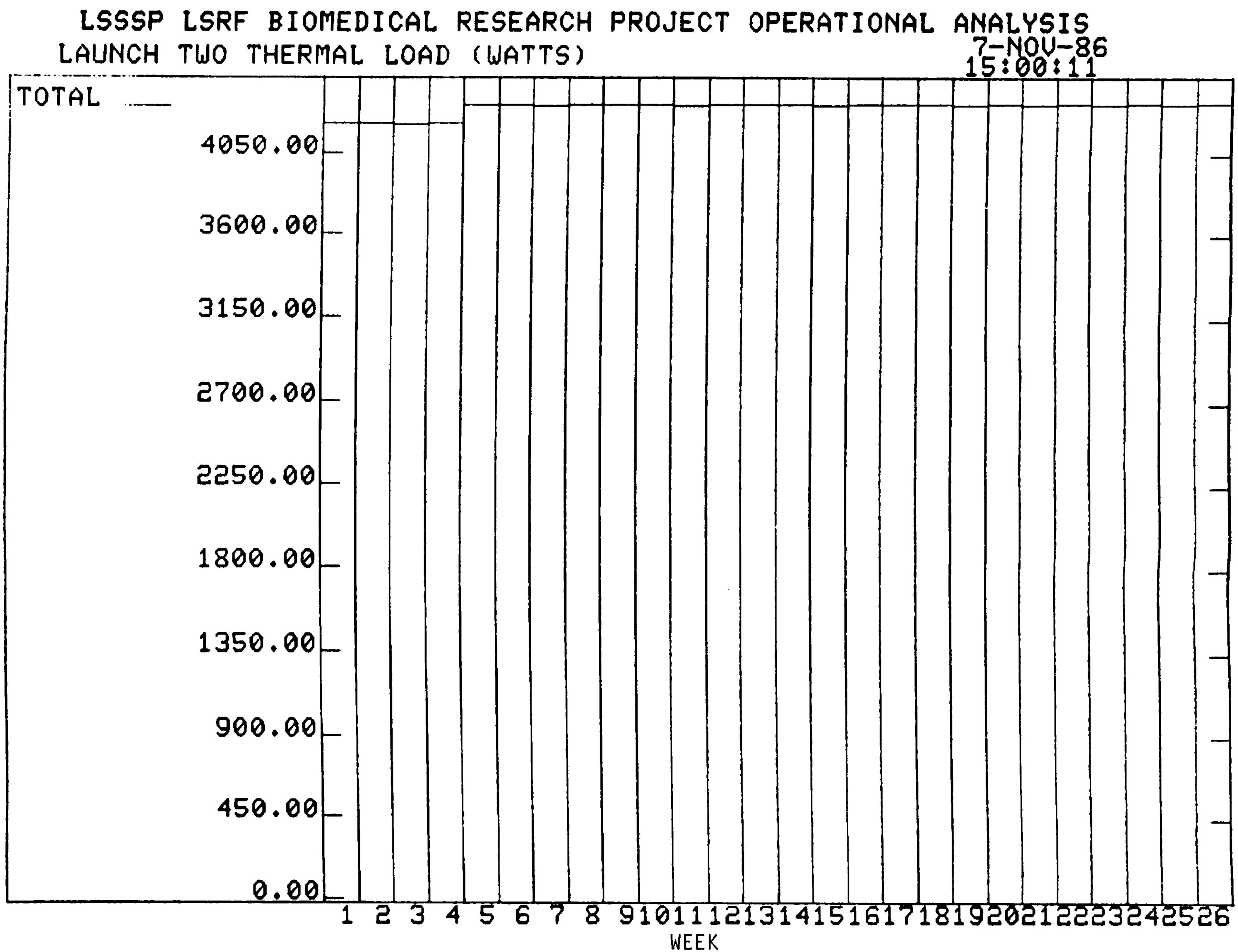
PHASED SEQUENCE TRAINING REQUIREMENTS: L-2

DISCIPLINE	NAME	OPERATOR	SUBJECT
ENDOCRINOLOGY/FLUID ELECTROLYTES			
	MEASUREMENT OF VENOUS PRESSURE AND PLASMA VOLUME	16	8
	EARLY AND LONG DURATION EFFECTS OF WEIGHTLESSNESS (m) *ASSUMES NON-INVASIVE VENOUS PRESSURE MEASUREMENT TECHNIQUE		
IMMUNOLOGY			
	DELAYED TYPE HYPERSENSITIVITY (t)	12	4
METABOLIC REGULATION: C) CELL BIOLOGY			
	EXOCRINE FUNCTION AND PROTEIN SECRETION IN SALIVARY GLANDS AS INFLUENCED BY MICROGRAVITY (MR/CB-A)	16	-
	MECHANISM OF CELLULAR RECEPTOR CHANGES SEEN IN MICROGRAVITY AS REFLECTED BY ASSOCIATED PHYSIOLOGICAL CHANGES (MR/CB-C)	20	-
	ENERGY UTILIZATION IN EUKARYOTIC ANG PROKARYOTIC CELLS IN MICROGRAVITY (MR/CB-D)	36	-
MUSCLE STRUCTURE & FUNCTION			
	MUSCLE LOSS IN RATS IN MICROGRAVITY (BIOCHEMISTRY) (MS/F-D)	32	-
NEUROSCIENCE			
	STRUCTURAL CHANGES IN THE RATS LABRYNTH IN MICROGRAVITY (NS-A)	32	-
	THE NATURE AND POTENTIAL CONSEQUENCES OF MICROGRAVITY-RELATED STRUCTURAL CHANGES IN CENTRAL PATHWAYS MEDIATING VESTIBULAR REFLEXES (NS-D)	24	-

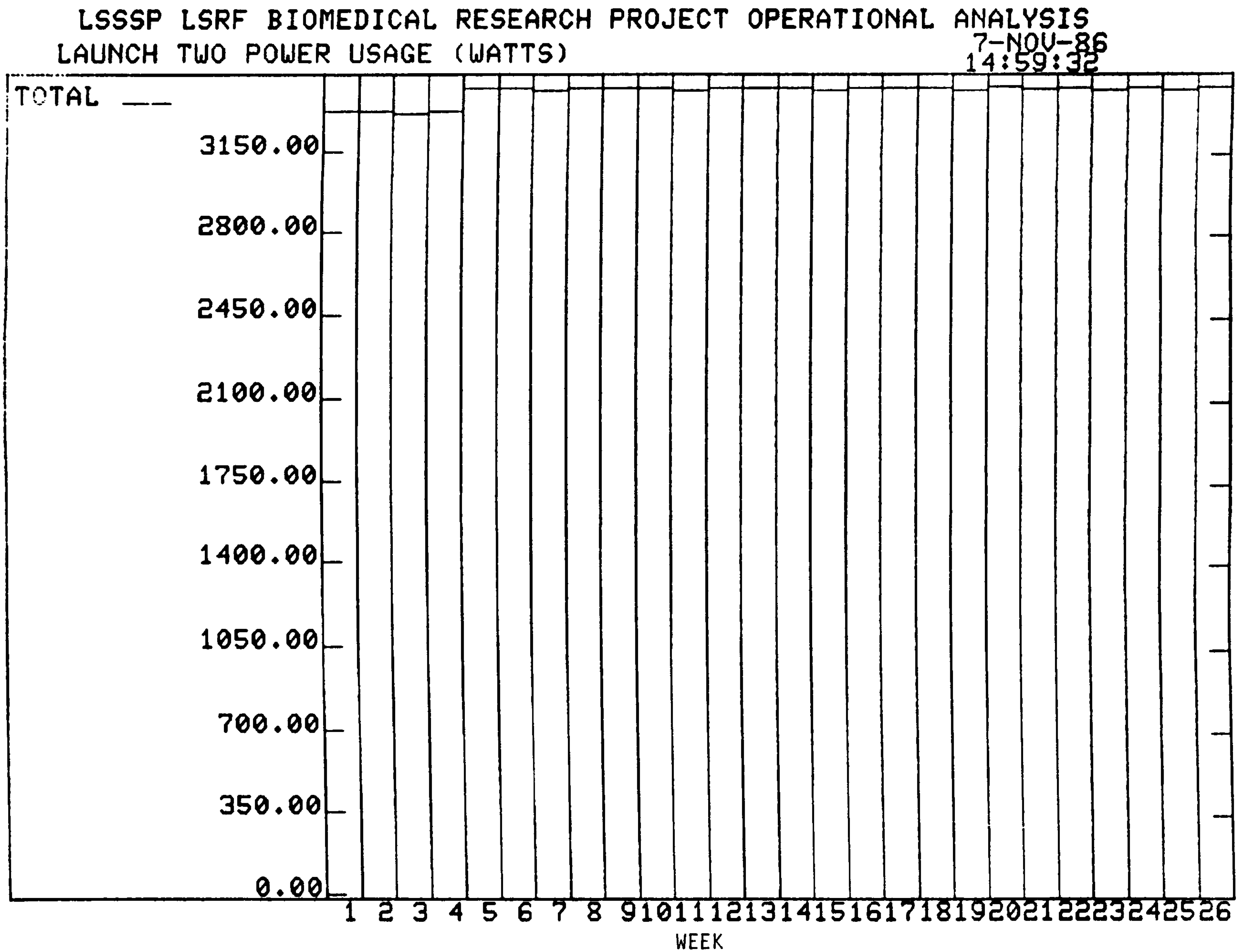
PHASED SEQUENCE TRAINING REQUIREMENTS: L-2

DISCIPLINE	NAME	OPERATOR	SUBJECT
PULMONARY PHYSIOLOGY			
	CAPABILITY TO STUDY INERT GAS EXCHANGE AS A FUNCTION OF TIME IN SPACE (aa)	16	32
	EVALUATE EVA WORK OUTPUT AND CARDIOVASCULAR RESPONSE (ab, ac)	24	16
	CAPABILITY TO EVALUATE EVA BUBBLE FORMATION (ad)	8	4
	MEASURE OF STANDARD PULMONARY FUNCTION (ah)	20	40
	TOTAL TASK	480	188
	TOTAL GENERIC	336	0
	TOTAL PHASE/INTEGRATED	80	0
	TOTAL L-2 TRAINING	896	188

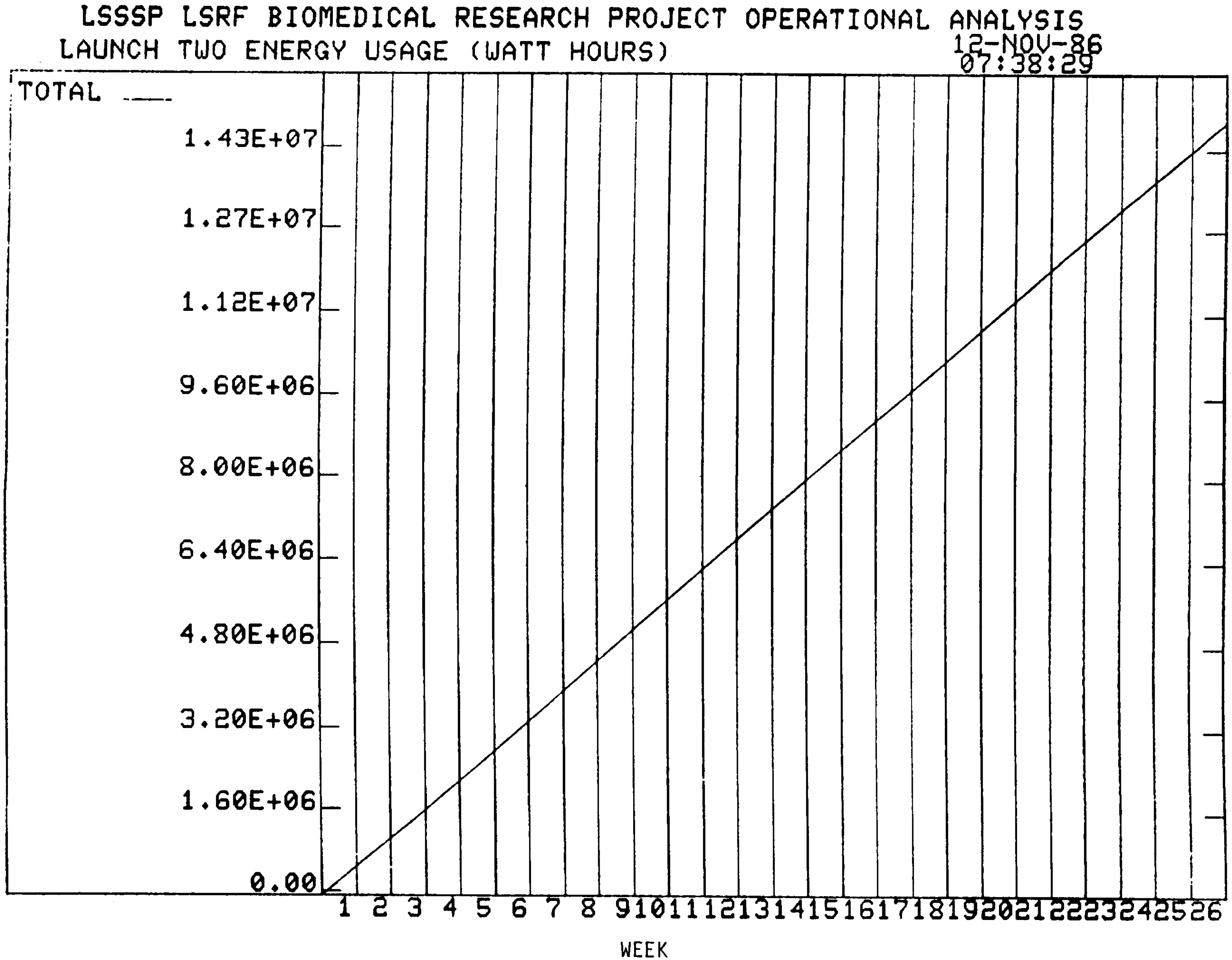
* A SAVING OF APPROXIMATELY 16 HOURS OF OPERATOR TRAINING TIME IS POSSIBLE DUE TO TASK SHARING IN CERTAIN RADIOBIOLOGY INVESTIGATIONS.



Thermal Load Profile for Launch 2

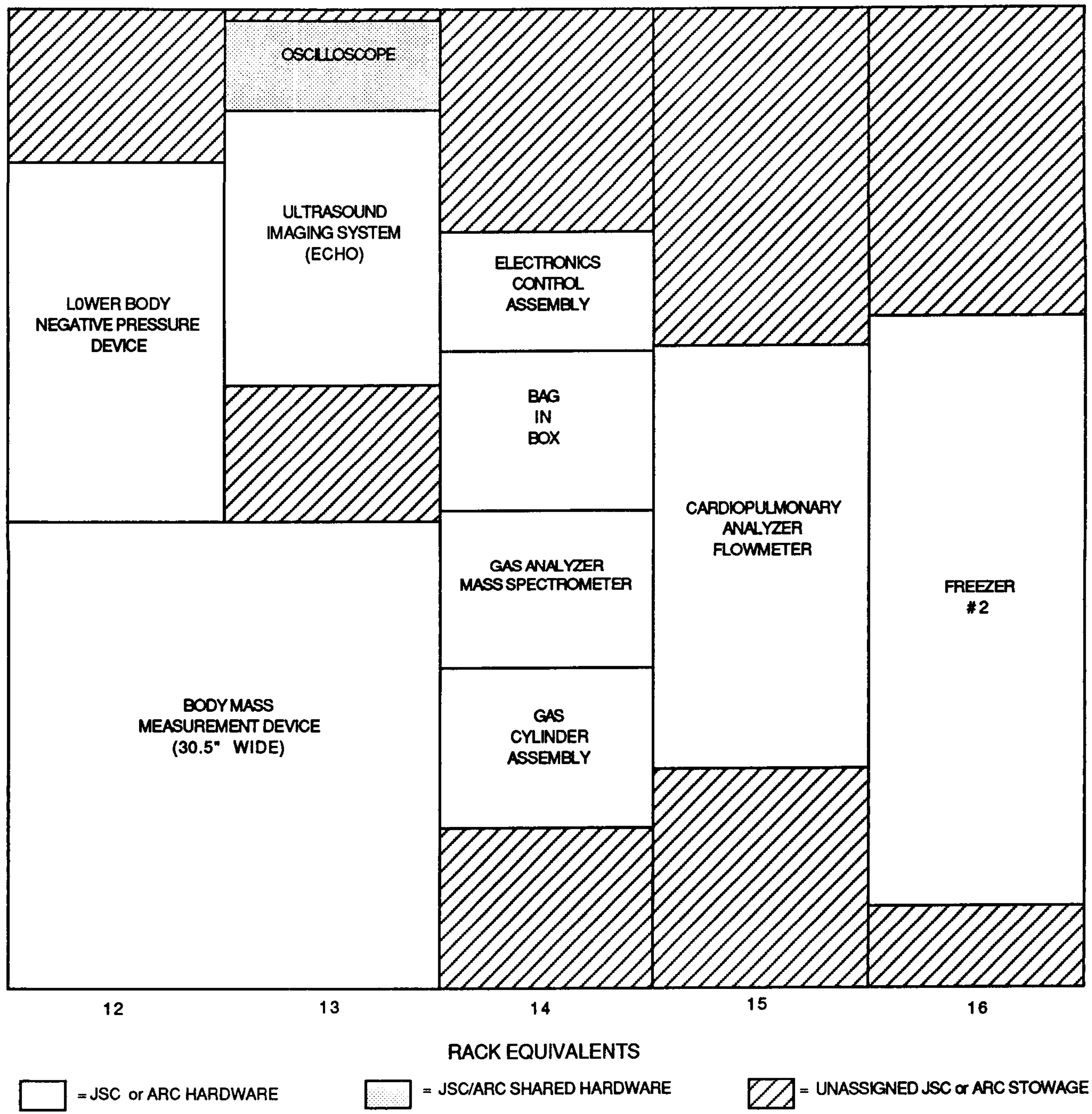


Power Profile for Launch 2



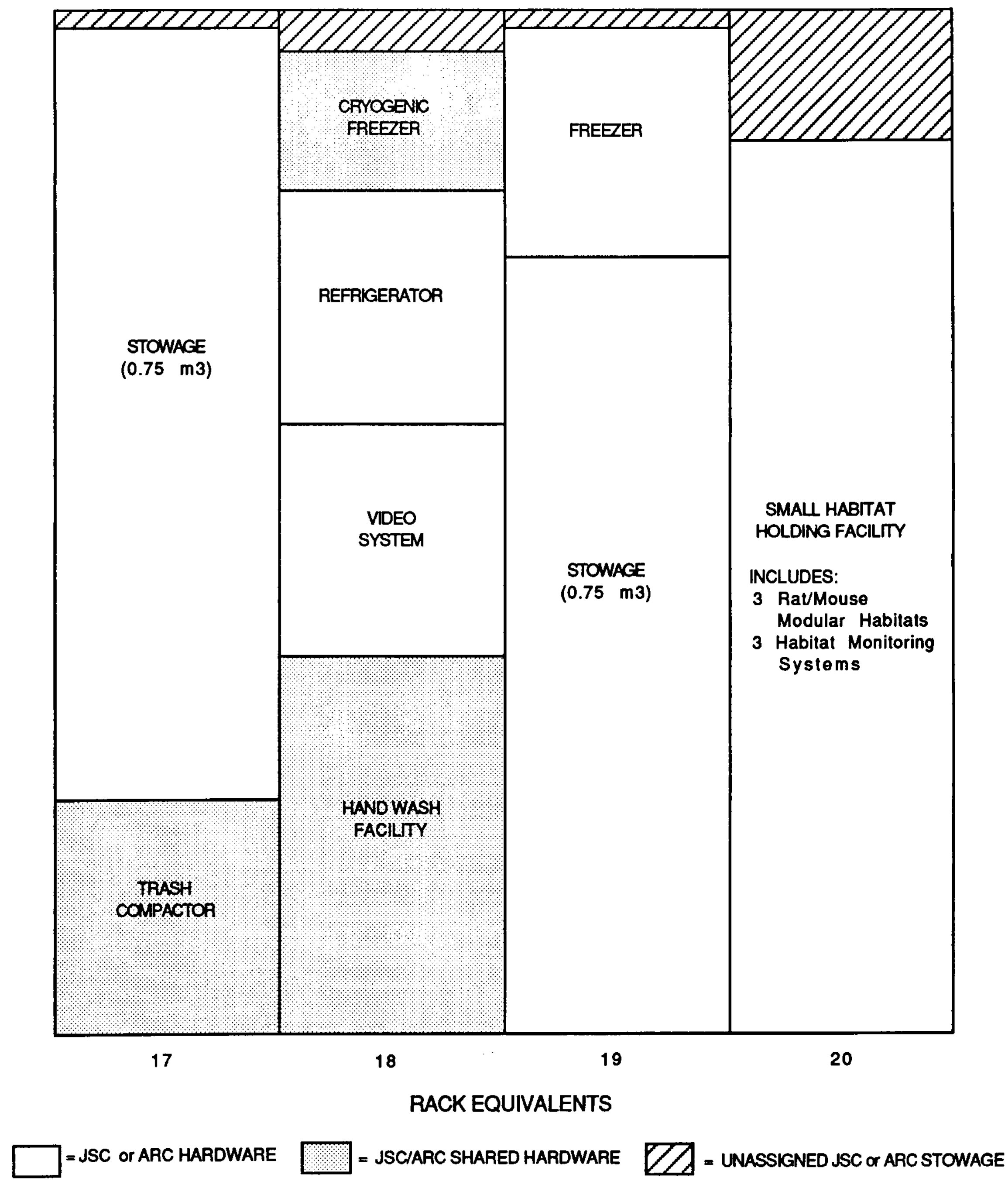
ENERGY PROFILE FOR LAUNCH TWO

PHASE 2



OSCILLOSCOPE
ULTRASOUND IMAGING SYSTEM (ECHO)
LOWER BODY NEGATIVE PRESSURE DEVICE
BODY MASS MEASUREMENT DEVICE (30.5" WIDE)
ELECTRONICS CONTROL ASSEMBLY
BAG IN BOX
GAS ANALYZER MASS SPECTROMETER
GAS CYLINDER ASSEMBLY
CARDIOPULMONARY ANALYZER FLOWMETER
FREEZER #2
12
13
14
15
16
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

PHASE 2



STOWAGE
(0.75 m3)
TRASH
COMPACTOR
CRYOGENIC
FREEZER
REFRIGERATOR
VIDEO
SYSTEM
HAND WASH
FACILITY
FREEZER
STOWAGE
(0.75 m3)
SMALL HABITAT
HOLDING FACILITY
INCLUDES:
3 Rat/Mouse
Modular Habitats
3 Habitat Monitoring
Systems
17
18
19
20
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

	PAYLOAD TOTALS					ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	Kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	••••••	••••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••
1	Bag-in-box	1	0.090	15.88	0	0.610	0.425	0.349	15.88	0	
2	Diagnostic Equipment	1	0.020	25.00	10	0.270	0.270	0.270	25.00	10	
3	Electronics Control Assembly	1	0.045	15.88	80	0.400	0.425	0.267	15.88	80	
4	Ergometer, Bicycle	1	0.120	13.61	10	0.400	0.500	0.599	13.61	10	
5	Exercise Device, Anaerobic	1	0.165	21.46	105	0.762	0.610	0.356	21.46	105	
6	Flowmeter, Cardiopul Analyzer	1	0.268	42.00	9	0.584	0.483	0.950	42.00	9	
7	Freezer #2	1	0.365	19.34	200	0.610	0.450	1.331	19.34	200	
8	Freezer (-70 deg C)	1	0.150	100.00	300	0.600	0.500	0.500	100.00	300	
9	Freezer, Cryogenic (-196°C)	1	0.090	20.00	0	0.600	0.500	0.300	20.00	0	
10	Gas Analyzer/Mass Spec	1	0.100	34.93	50	0.584	0.483	0.356	34.93	50	
11	Gas Cylinder Assembly	1	0.092	42.00	0	0.610	0.425	0.356	42.00	0	
12	Habitat monitoring system	6	0.000	120.00	150	0.406	0.355	0.152	20.00	25	Included in Holding Facility
13	Hand Wash Facility	1	0.320	100.00	375	0.800	0.500	0.800	100.00	375	
14	Imaging System, Ultrasound	1	0.179	90.72	600	0.609	0.483	0.609	90.72	600	
15	L B N P Device	1	0.293	19.05	55	0.762	0.483	0.795	19.05	55	
16	Mass Meas. Device, Body	1	0.067	34.02	15	1.029	0.083	0.795	34.02	15	
17	Monitor, Heart Rate	1	0.000	0.95	10	0.102	0.051	0.025	0.95	10	
18	Oscilloscope	1	0.030	14.00	100	0.300	0.500	0.200	14.00	100	
19	Rat/Mouse Modular Habitat	3	0.000	90.00	150	0.660	0.406	0.356	30.00	50	Included in Holding Facility
20	Rat/Mouse Modular Habitat (0.1 cu m)	6	0.572	180.00	300	0.660	0.406	0.356	30.00	50	
21	Rat/Mouse Modular Habitat (0.1 cu m)	3	0.286	90.00	300	0.660	0.406	0.356	30.00	50	
22	Refrigerator	1	0.150	100.00	200	0.600	0.500	0.500	100.00	200	
23	Rowing Machine	1	0.220	17.24	0	1.219	0.711	0.254	17.24	0	
24	Small Habitat Holding Facility	1	0.750	150.00	250				150.00	250	
25	Trash Compactor	1	0.200	30.00	250	0.800	0.500	0.500	30.00	250	
26	Treadmill	1	0.311	11.79	25	1.219	0.559	0.457	11.79	25	
27											
28											
29	TOTALS FOR RACK MOUNTED HARDWARE		4.886	1397.87	3544						
30											
31											

ORIGINAL PAGE IS
OF POOR QUALITY

LAUNCH 2 STOWED - REFERENCE MISSION OPERATIONAL ANALYSIS DOCUMENT

	PAYLOAD TOTALS					ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	Kg	watts	m	m	m	kg	watts	REMARKS*
•••	••••••••••••••••••••••••••••••	••••••	••••••	••••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	•••••••••••••••••••••••••••••••••
1	A L F E Stowage Kit	1	0.015	2.00	0	0.249	0.249	0.249	2.00	0	
2	Bag Assembly, Expmt O2, Spare	1	0.004	2.99	0	0.432	0.102	0.102	2.99	0	
3	Calibration Syringe, 3 Liter	1	0.023	2.99	0	0.579	0.201	0.201	2.99	0	
4	Cleaning Equipment	1	0.100	25.00	50	0.464	0.464	0.464	25.00	50	
5	Electrode Kit, Nerve	78	0.007	5.89	0	0.203	0.076	0.006	0.08	0	
6	Fixation Kit	1	0.120	20.00	0	0.600	0.500	0.400	20.00	0	
7	Food (ea. Rat/90 day)	24	0.120	72.00	0	0.173	0.170	0.170	3.00	0	
8	Food (ea. Rat/90 day)	24	0.120	72.00	0	0.173	0.170	0.170	3.00	0	
9	Gas Tanks/Gas Supplies	1	0.031	9.98	25	0.371	0.472	0.175	9.98	25	
10	Mask/Regulator System	1	0.001	22.00	0	0.102	0.102	0.102	22.00	0	
11	Monitor System, Physiological	1	0.001	0.91	100	0.051	0.102	0.119	0.91	100	
12	Monitor, Environmental	1	0.033	25.40	20	0.305	0.305	0.356	25.40	20	
13	Nerve Conduction Vel. Tester	1	0.002	2.84	25	0.102	0.483	0.044	2.84	25	
14	P M S Accessories	26	0.491	1.00	0	0.610	0.152	0.203	0.04	0	
15	Rebreathing Assembly	6	0.161	36.00	0	0.432	0.249	0.249	6.00	0	
16	Spares, Hardware	1	0.100	50.00	0	0.464	0.464	0.464	50.00	0	
17	Specimens (Rats)	24	0.000	12.00	0				0.50	0	In Habitat Modules
18	Specimens (Rats)	24	0.000	12.00	0				0.50	0	In Habitat Modules
19	Spirometer Assembly	1	0.006	1.00	0	0.305	0.203	0.102	1.00	0	
20	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
21	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
22	Tools	1	0.020	30.00	0	0.270	0.270	0.270	30.00	0	
23	Video Tapes	20	0.038	5.00	0	0.500	0.500	0.150	0.25	0	
24	Waste Tray	338	0.703	307.58	0	0.128	0.128	0.127	0.91	0	
25	Water for cage washer (liters)	410	0.410	410.00	0	0.100	0.100	0.100	1.00	0	RESUPPLY AT 10% OF INITIAL LOAD
26	Water (ea. Rat/90 day)	24	0.120	120.00	0	0.173	0.170	0.170	5.00	0	
27	Water (ea. Rat/90 day)	24	0.120	120.00	0	0.173	0.170	0.170	5.00	0	
28	Wipes, Dry	1	0.001	0.10	0	0.150	0.100	0.050	0.10	0	
29	Wipes, Wet	1	0.002	0.10	0	0.150	0.100	0.100	0.10	0	
30	Failed Hardware Replacements (10%)		1.961	633.195							
31	Hardware For Changeout (2.5%)		0.49	158.299							
32											
33											
34	TOTALS FOR STOWED ITEMS		8.049	2760.28	220						
35											
36											

	PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	Kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••
1	Rat/Mouse Modular Habitat (0.1 cu m)	9	0.859	270.00	300	0.660	0.406	0.356	30.00	50	
2	Samples, Frozen		0.003	0.00279							
3	Samples, Ambient or Refrigerated		0.005	0.00418							
4	Specimens (Rats)	36	0.000	18.00	0				0.50	0	In Habitat Modules
5	Waste, Solid		3.589	883.4							
6	Waste, Liquid		0.423	1024.13							
7	Failed Hardware (10%)		1.961	633.195							
8	Hardware From Changeout (2.5%)		0.49	158.299							
9											
10											
11	Total for Launch -2 Return		6.471	2717.03							
12											
13											

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	PAYLOAD TOTALS					ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	Kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	••••••	•••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••
1	A L F E Stowage Kit	1	0.015	2.00	0	0.249	0.249	0.249	2.00	0	
2	Electrode Kit, Nerve	78	0.007	5.89	0	0.203	0.076	0.006	0.08	0	
3	Fixation Kit	1	0.120	20.00	0	0.600	0.500	0.400	20.00	0	
4	Food (ea. Rat/90 day)	24	0.120	72.00	0	0.173	0.170	0.170	3.00	0	
5	Food (ea. Rat/90 day)	24	0.120	72.00	0	0.173	0.170	0.170	3.00	0	
6	Gas Tanks/Gas Supplies	1	0.031	9.98	25	0.371	0.472	0.175	9.98	25	
7	P M S Accessories	26	0.491	1.00	0	0.610	0.152	0.203	0.04	0	
8	Specimens (Rats)	48	0.000	24.00	0				0.50	0	Included in Habitat Module
9	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
10	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
11	Video Tapes	1	0.038	5.00	0	0.500	0.500	0.150	5.00	0	
12	Waste Tray	338	0.703	307.58		0.128	0.128	0.127	0.91	0	
13	Water for cage washer (liters)	41	0.041	41.00		0.100	0.100	0.100	1.00	0	RESUPPLY AT 10% OF INITIAL LOAD
14	Water (ea. Rat/90 day)	24	0.120	120.00	0	0.173	0.170	0.170	5.00	0	
15	Water (ea. Rat/90 day)	24	0.120	120.00	0	0.173	0.170	0.170	5.00	0	
16	Wipes, Dry	1	0.001	0.10	0	0.150	0.100	0.050	0.10	0	
17	Wipes, Wet	1	0.002	0.10	0	0.150	0.100	0.100	0.10	0	
18	Failed Hardware Replacements (10%)		2.304	773.261							
19	Hardware For Changeout (2.5%)		0.576	193.315							
20											
21											
22	TOTALS FOR RESUPPLY ITEMS		7.579	2367.23	25						
23											
24											

	PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	Kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	••••••	••••••••	•••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••••
1	Samples, Frozen		0.003	0.00295							
2	Samples, Ambient or Refrigerated		0.415	41.0044							
3	Waste, Solid		3.589	883.4							
4	Waste, Liquid		0.423	1024.13							
5	Failed Hardware (10%)		0.343	140.065							
6	Hardware From Changeout (2.5%)		0.47	144.148							
7											
8											
9	Total for Launch -2A Return		5.243	2232.75							
10											
11											

APPENDIX E

LAUNCH PHASE 3

APPENDIX E TABLE OF CONTENTS

PHASE 3 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Neuromuscular Activity (f)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Neuromuscular Potential Output (g)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Muscular Adaptation and Readaptation (k)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Exercise Program (l)*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Venous Pressure and Plasma Measurement (m)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Psychosocial Support (o)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Group Interaction (p)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Problem Solving (q)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Visual Compensation (v,w)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Drug Pharmacokinetics & Drug Monitoring (y,z)	X			X			X			X				X			X			X			X			
Inert Gas Exchange (aa)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EVA Bubble Formation (ad)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pulmonary Function (ah)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Microbial Study (ai,aj)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Plant Nutrient/Water Systems (PL-A)														X	X	X	X	X	X	X	X	X	X	X	X	X
Plant Support/Orientation Mechanisms (PL-B)														X	X	X	X	X	X	X	X	X	X	X	X	X
Plant Development (PL-E)														X	X	X	X	X	X	X	X	X	X	X	X	X
Amyloplast Development (PL-I)														X	X	X	X	X	X	X	X	X	X	X	X	X
Radiation on the Retina (RA-D)																										
Cataract Formation (RA-E)																										
Radiation on Hair Follicles (RA-F)														X	X	X	X	X	X	X	X	X	X	X	X	X
Radiation on Stem Cells of Skin (RA-G)																										

NOTES: Weeks 1-3 for integration of equipment. * Exercise perfomed daily not charged to life sciences

PHASE 3 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Muscle Loss in Rats II (MS/F-B)			X		X				X				X													

NOTES: Weeks 1-3 for integration of equipment.

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 3 - BmRP

Experiment	Hours
f	82.3
g	58.5
k	189.8
l*	1422.0*
m	7.8
o	39.0
p	26.0
q	78.0
v,w	132.6
y,z	19.2
aa	69.8
ad	32.5
ah	145.1
ai,aj	20.8
SUB-TOTAL BmRP	901.4

* EXERCISE, NOT CHARGED TO LIFE SCIENCES

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 3 - BRP

Experiment	Hours
RA-D	0.0
RA-E	0.0
RA-F	1.0
RA-G	0.0
PL-A	25.0
PL-B	35.0
PL-E	1.0
PL-I	1.0
MS/F-B	84.0
Specimen Servicing	364.0
SUBTOTAL BRP	511.0
SUBTOTAL BmRP	901.4
HARDWARE SERVICE/MAIN.	156.0
TOTAL PHASE 3	1568.4

SKILL MIX ASSESSMENT - LAUNCH 3

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
MUSCLE PHYSIOLOGY (f,g)	DON ACCELEROMETER DON FORCE MEAS. DEVICE	NONE (SKILLED)	HEALTHY (NO PREVIOUS HISTORY OF MUSCLE DISEASE)	NO	
EXERCISE PHYSIOLOGY (k,l)	PERFORM ISOKINETIC EXERCISE PERFORM AEROBIC EXERCISE PERFORM ANAEROBIC EXERCISE	NONE (SKILLED)	HEALTHY	NO	
ENDOCRINOLOGY/ FLUID ELECTROLYTES (m)	URINE COLLECTION SAMPLE PREP VENOUS PRES.	NONE (SKILLED)	HEALTHY	NO	
BEHAVIORAL RESEARCH (o,p,q)	DATA PUNCH (COMPUTER QUEST.)	NONE (SKILLED)	NONE	NO	
NEUROSCIENCE (v,w)	OCULAR NYSTAGMUS (OPERATION OF QUALITY CONTROL & DISPLAY SYSTEM)	NONE (SKILLED)	HEALTHY (NORMAL VESTIBULAR RESPONSES SUBJ. WITH EXTREME SUSCEPTIBILITY TO SPACE MOTION SICK-NESS NOT ACCEPTABLE)	NO	

SKILL MIX ASSESSMENT - LAUNCH 3

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
PHARMACOKINETICS (y,z)	URINE COLLECTION SAMPLE PREP ST'D LAB EQUIPMENT OPERATION DRUG ADM	NONE (SKILLED)	HEALTHY	NO	
PULMONARY PHYSIOLOGY (aa,ad,ah)	REBR. DEVICE BMMD SAMPLE PREP ALFE OPERATION	NONE (SKILLED)	HEALTHY (NON-SMOKERS)	NO	
MICROBIOLOGY (ai,aj)	SAMPLE COLLECTION PHOTOMICROGRAPH OPERATION INCUBATOR OPERATION	NONE (SKILLED)	NONE	NO	
PLANT PHYSIOLOGY (PL-A,PL-B,PL-E, PL-I)	PLANT GROWTH HARVEST PLANTS FREEZE VIDEO MONITORING OF PLANT GROWTH PLANT TISSUE CULTURE PLANT FIXATION	NONE (SKILLED)	NONE	N/A	N/A

2

SKILL MIX ASSESSMENT - LAUNCH 3

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
RADIATION EFFECTS (RA-D,RA-E RA-F,RA-G)	READ DOSIMETER RECORD ANIMAL SURGERY TISSUE COLLECTION TISSUE FIXATION HORMONE ASSAYS RIA ASSAY APLEEN COLONY ASSAY PERFUSION OF RATS	NONE (SKILLED)	HEALTHY 100 MICE (RA-L) 12 RATS (RA-K) 20mm, 60 OPT RATS OR MICE (RA-L)		NO
MUSCLE STRUCTURE & FUNCTION (MS/F-B)	SMALL ANIMAL SURG. CLAMP-FREEZE TISSUE TISSUE FIXATION BIOCHEMICAL ANALY. OF TISSUE MEASURE CONTRACTIL PROPERTIES MONITOR EMG ACTIV.	NONE (SKILLED)	16 RATS (B)		YES ADULT MALE RATS

PHASED SEQUENCE TRAINING REQUIREMENTS: L-3

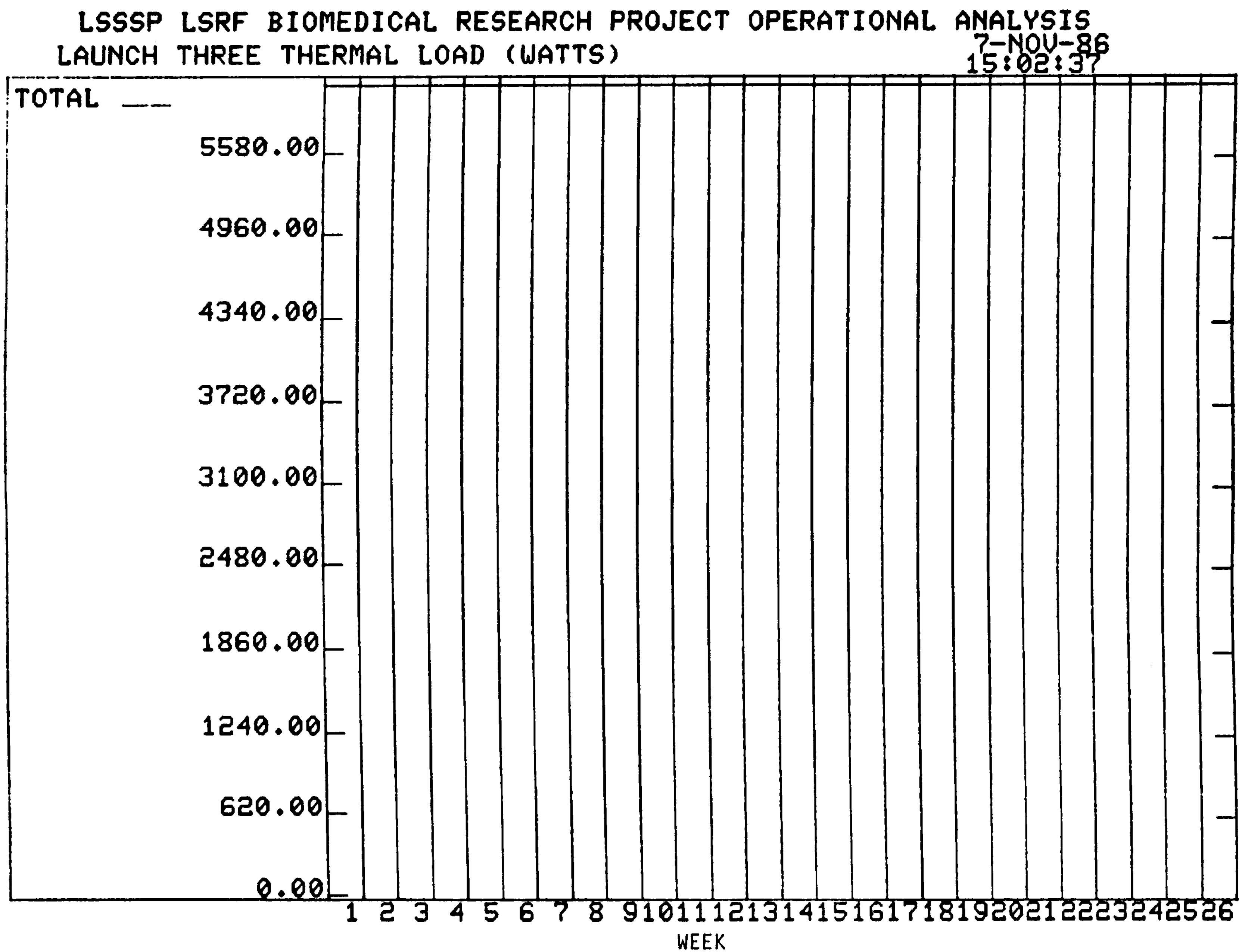
DISCIPLINE / NAME	OPERATOR	SUBJECT
MUSCLE STRUCTURE & FUNCTION		
MUSCLE LOSS IN RATS IN MICROGRAVITY (ELECTRON MICROSCOPY/ULTRASTRUCTURE) (MS/F-B)	36	-
MUSCLE PHYSIOLOGY		
MEASUREMENT OF INFLIGHT NEUROMUSCULAR ACTIVITY (f)	30	15
NEUROMUSCULAR POTENTIAL OUTPUT DURING SPACEFLIGHT (g)	32	16
PLANT PHYSIOLOGY		
OPTIMIZATION OF PLANT NUTRIENT AND WATER SUPPLY SYSTEMS (PL-A)	8	-
OPTIMIZATION OF PLANT SUPPORT AND ORIENTATION MECHANISMS FOR USE IN MICROGRAVITY (PL-B)	8	-
ROLE OF MICROGRAVITY IN CONTROL OF DEVELOPMENT AT THE ORGAN AND CELLULAR LEVEL (PL-E)	16	-
EFFECT OF MICROGRAVITY ON AMYLOPLAST DEVELOPMENT (PL-I)	16	-
RABIOBIOLOGY		
EFFECTS OF SPACE RADIATION ON THE RETINA (RA-D)	4	-
POSSIBLE CATARACT FORMATION/HAZARD DURING SPACEFLIGHT (RA-E)	4	-
EFFECTS OF SPACE RADIATION ON HAIR FOLLICLES (RA-F)	4	-

PHASED SEQUENCE TRAINING REQUIREMENTS: L-3

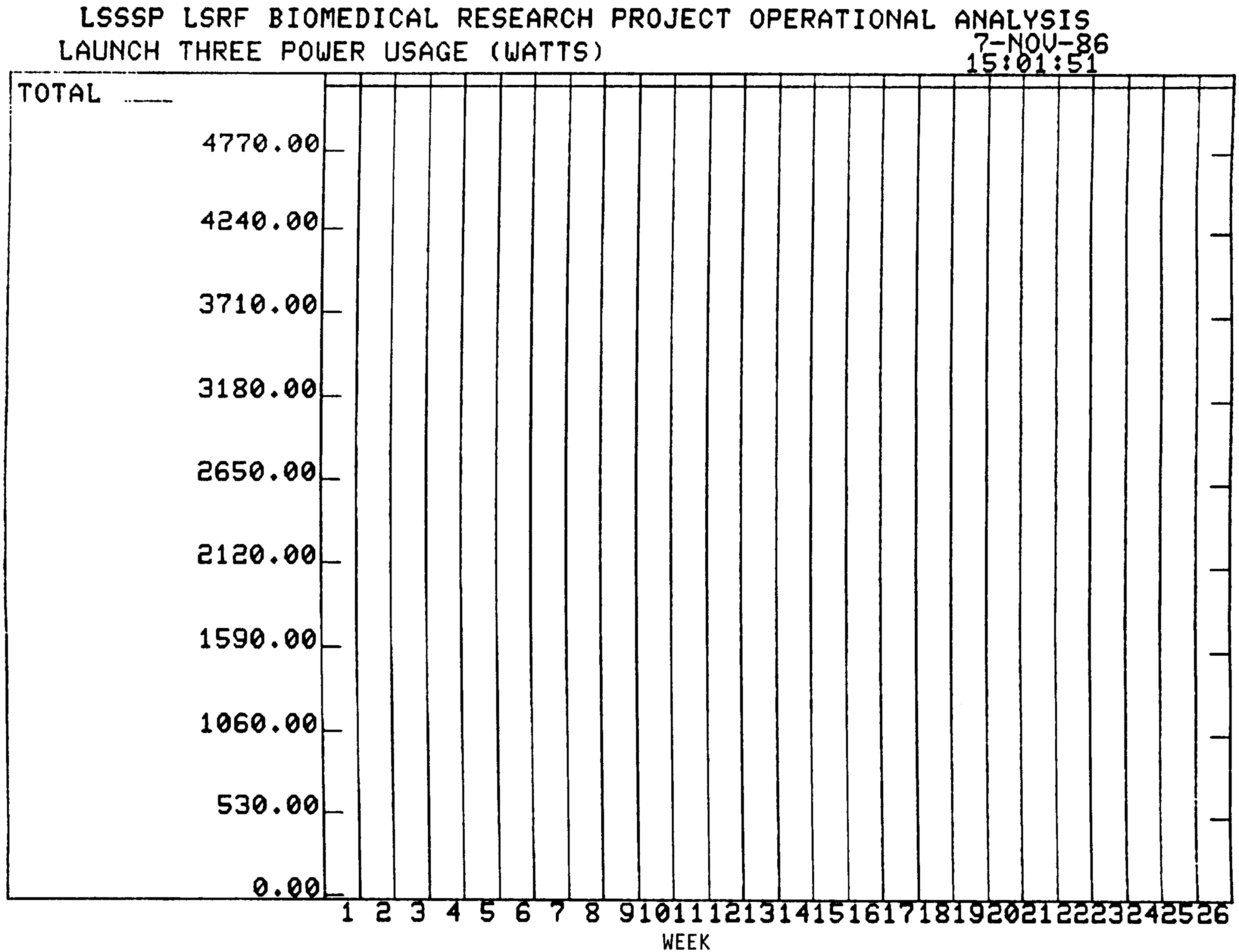
DISCIPLINE	NAME	OPERATOR	SUBJECT
	RADIATION DAMAGE TO STEM CELLS OF SKIN (RA-G)	4	-
EXERCISE PHYSIOLOGY			
	MUSCLE ADAPTATION AND READAPTATION (MUSCLE PERFORMANCE CHANGES) (k)	8	16
	EXERCISE PROGRAM FOR SPACEFLIGHT (l)	8	8
ENDOCRINOLOGY/FLUID ELECTROLYTES			
	MEASUREMENT OF VENOUS PRESSURE AND PLASMA VOLUME EARLY AND LONG DURATION EFFECTS OF WEIGHTLESSNESS (m) *ASSUMES NON-INVASIVE VENOUS PRESSURE MEASUREMENT TECHNIQUE	16	8
BEHAVIORAL RESEARCH			
	THE EFFECTIVENESS OF INDIVIDUALLY TAILORED PSYCHOSOCIAL SUPPORT METHODS IN ACTUAL SPACEFLIGHT SETTINGS (o)	8	-
	GROUP INTERACTION, COMPATIBILITY, AND EFFECTIVENESS (p)	8	-
	PROBLEM SOLVING (q)		
NEUROSCIENCE			
	VESTIBULO-VISUAL AND CANALICULAR-OTOLITH COMPENSATION (v, w)	40	20

PHASED SEQUENCE TRAINING REQUIREMENTS: L-3

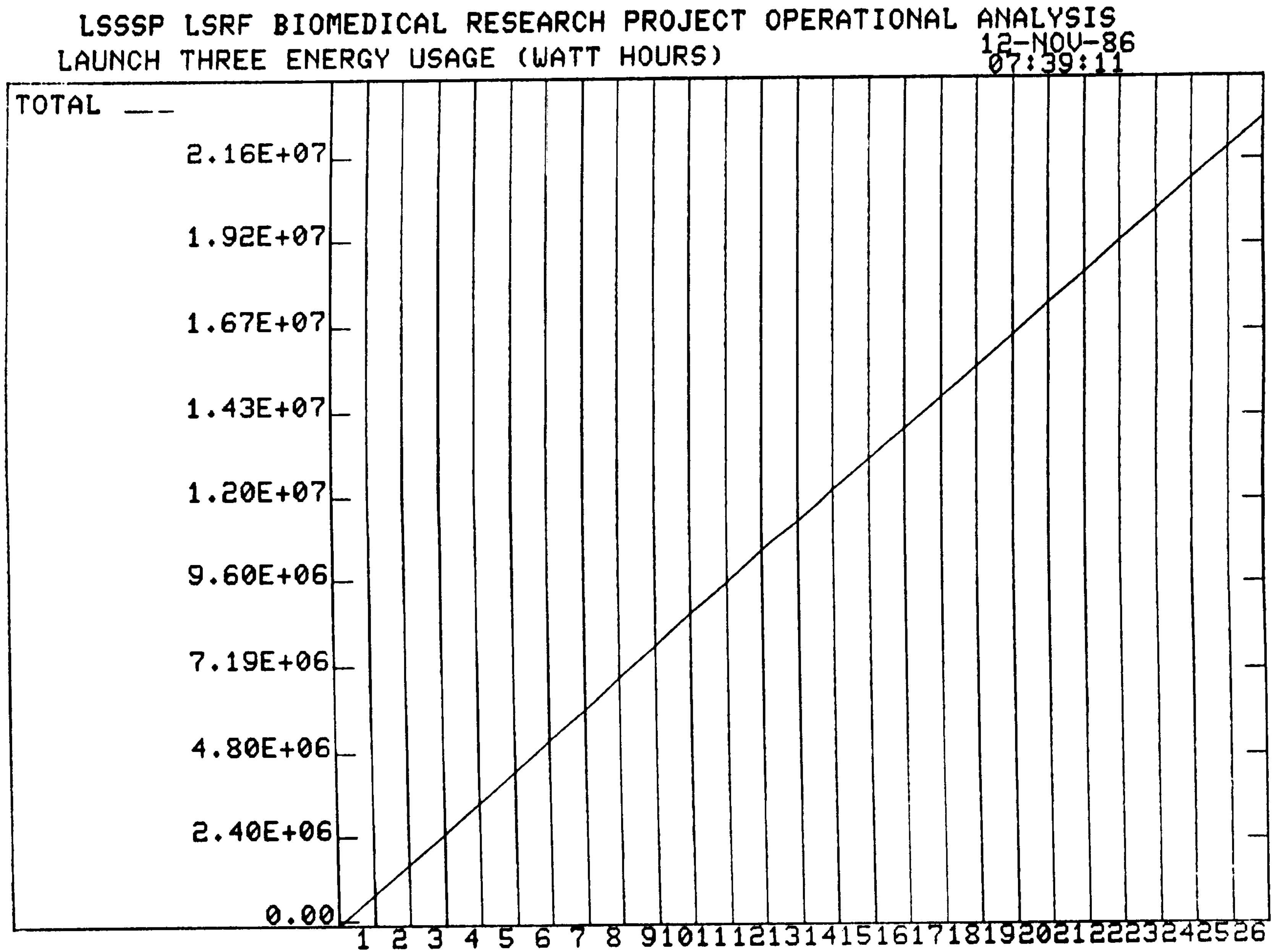
DISCIPLINE	NAME	OPERATOR	SUBJECT
PHARMACOKINETICS			
	DRUG PHARMACOKINETICS IN SPACE AND EVALUATION OF MODERN NON-INVASIVE METHODS FOR CLINICAL DRUG MONITORING (y, z)	16	8
PULMONARY PHYSIOLOGY			
	CAPABILITY TO STUDY INERT GAS EXCHANGE AS A FUNCTION OF TIME IN SPACE (aa)	16	32
	CAPABILITY TO EVALUATE EVA BUBBLE FORMATION (ad)	8	4
	MEASURE OF STANDARD PULMONARY FUNCTION (ah)	20	40
MICROBIOLOGY			
	CREWMEMBER AND SPACE STATION MICROBIAL STUDY (ai, aj)	16	8
	TOTAL TASK	342	175
	TOTAL GENERIC	336	0
	TOTAL PHASE/INTEGRATED	80	0
	TOTAL L-3 TRAINING	758	175



Thermal Load Profile for Launch 3

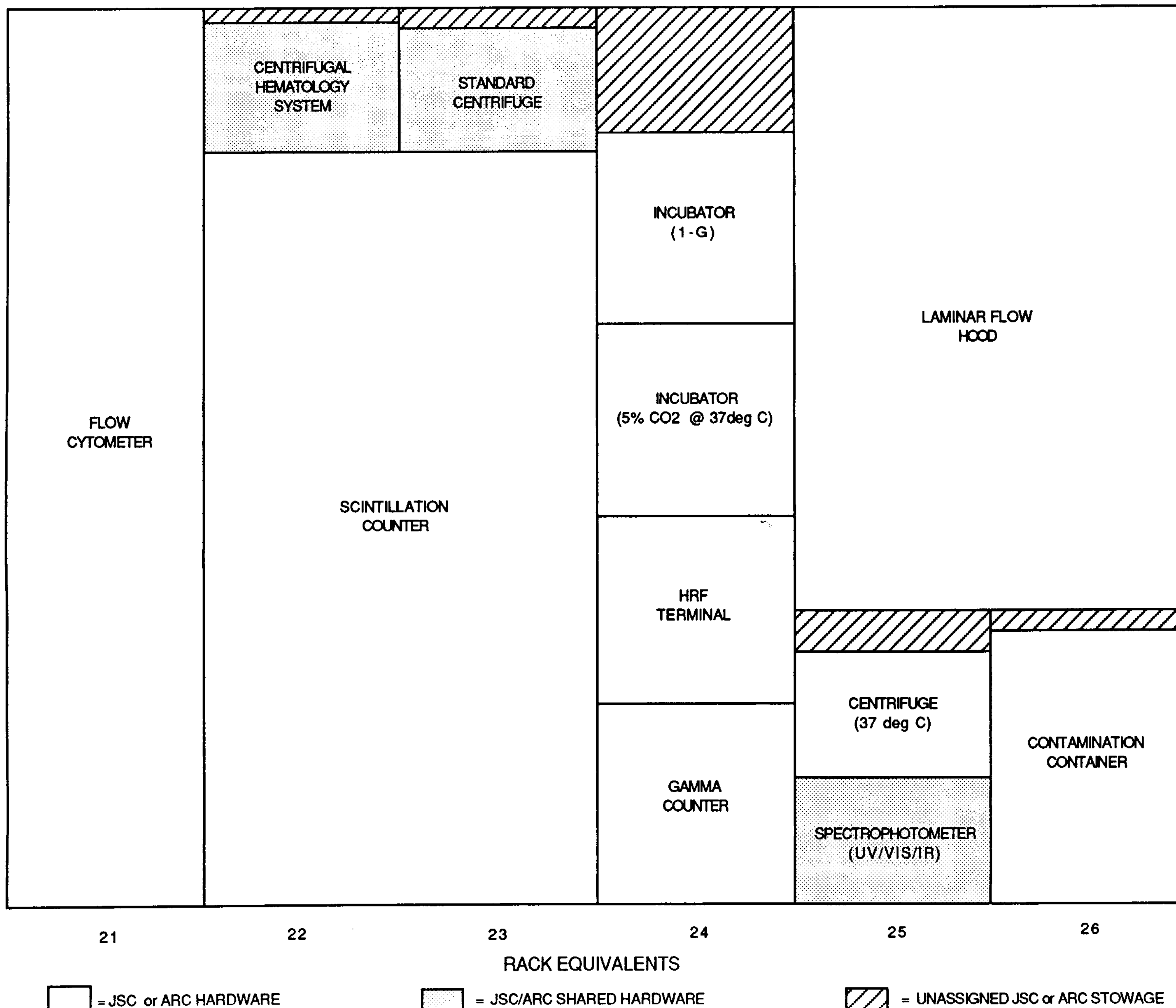


Power Profile for Launch 3



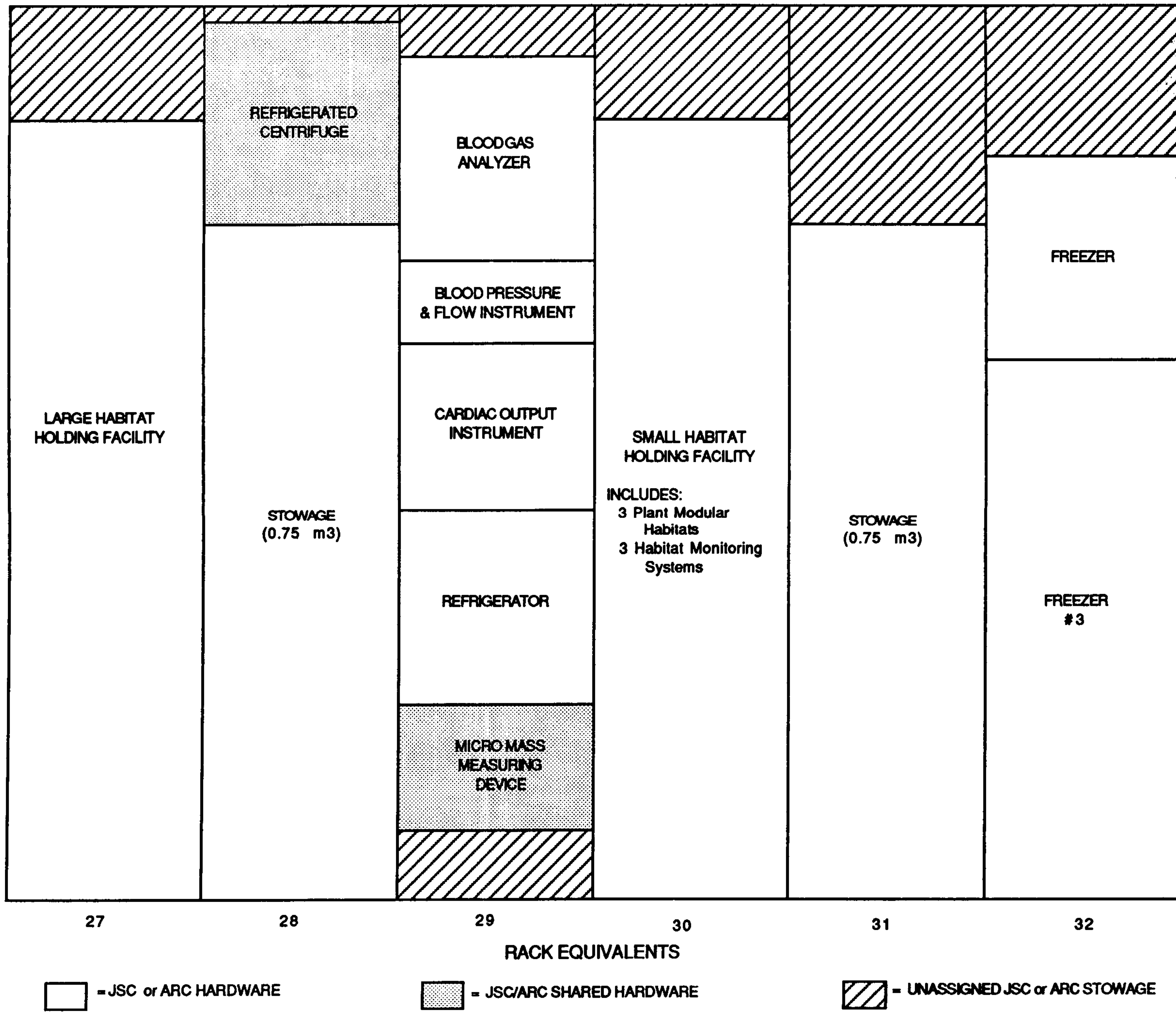
ENERGY PROFILE FOR LAUNCH THREE

PHASE 3



CENTRIFUGAL HEMATOLOGY SYSTEM
STANDARD CENTRIFUGE
FLOW CYTOMETER
SCINTILLATION COUNTER
INCUBATOR (1-G)
INCUBATOR (5% CO2 @ 37deg C)
HRF TERMINAL
GAMMA COUNTER
LAMINAR FLOW HOOD
CENTRIFUGE (37 deg C)
SPECTROPHOTOMETER (UV/VIS/IR)
CONTAMINATION CONTAINER
21
22
23
24
25
26
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

PHASE 3


LARGE HABITAT HOLDING FACILITY
REFRIGERATED CENTRIFUGE
STOWAGE (0.75 m3)
BLOOD GAS ANALYZER
BLOOD PRESSURE & FLOW INSTRUMENT
CARDIAC OUTPUT INSTRUMENT
REFRIGERATOR
MICRO MASS MEASURING DEVICE
SMALL HABITAT HOLDING FACILITY
INCLUDES:
3 Plant Modular Habitats
3 Habitat Monitoring Systems
STOWAGE (0.75 m3)
FREEZER
FREEZER #3
27
28
29
30
31
32
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

		PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	••••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	•••••••	•••••••••••••••••••••••••••••••••
1	Biotelemetry System	1	0.030	30.00	50	0.300	0.500	0.200	30.00	50	
2	Blood Gas Analyzer	1	0.125	45.00	250	0.500	0.500	0.500	45.00	250	
3	Cardiac Output Instrumentation (animal	1	0.080	10.00	75	0.400	0.500	0.400	10.00	75	
4	Centrifugal Hematology System	1	0.016	22.68	200	0.229	0.229	0.311	22.68	200	
5	Centrifuge, 37 deg C	1	0.090	30.00	450	0.600	0.500	0.300	30.00	450	
6	Centrifuge, Refrigerated	1	0.200	40.00	450	0.800	0.500	0.500	40.00	450	
7	Centrifuge, Standard Lab	1	0.090	30.00	350	0.600	0.500	0.300	30.00	350	
8	Container, Contamination	1	0.243	54.43	0	0.762	0.483	0.660	54.43	0	
9	Counter, Scintillation	1	1.255	181.44	500	1.829	0.711	0.965	181.44	500	
10	Flow Cytometer	1	1.000	136.08	500	0.914	0.483	2.266	136.08	500	
11	Freezer #3	1	0.365	19.34	200	0.610	0.450	1.331	19.34	200	
12	Freezer (-70 deg C)	1	0.150	100.00	300	0.600	0.500	0.500	100.00	300	
13	Gamma Counter	1	0.173	183.00	10	0.686	0.495	0.508	183.00	10	
14	Habitat monitoring system (Rhesus)	1	0.000	20.00	25	0.406	0.355	0.152	20.00	25	Included in Holding Facility
15	Habitat monitoring system	3	0.000	60.00	75	0.406	0.355	0.152	20.00	25	Included in Holding Facility
16	Incubator (1g)	1	0.142	27.22	100	0.632	0.483	0.464	27.22	100	
17	Incubator (5% CO2@37°C)	1	0.142	27.22	100	0.632	0.483	0.464	27.22	100	
18	Laminar Flow Hood	1	0.690	77.00	500	0.724	1.470	0.648	77.00	500	
19	Large Habitat Holding Facility	1	1.027	150.00	250	0.910	0.530	2.130	150.00	250	
20	Mass Meas. Device, Micro	1	0.075	15.00	15	0.500	0.500	0.300	15.00	15	
21	Plant Modular Habitat	3	0.000	120.00	750	0.660	0.406	0.356	40.00	250	Included in Holding Facility
22	Refrigerator	1	0.150	100.00	200	0.600	0.500	0.500	100.00	200	
23	Rhesus Modular Habitat	1	0.000	150.00	250	0.660	0.406	0.712	150.00	250	Included in Holding Facility
24	Small Habitat Holding Facility	1	0.750	150.00	250	0.910	0.530	2.130	150.00	250	Included in Holding Facility
25	Spectrophotometer (Visual, UV, IR)	1	0.099	40.00	300	0.660	0.500	0.300	40.00	300	
26											
27											
28	TOTALS FOR RACK MOUNTED EQUIPMENT		6.892	1818.41	6150						
29											
30											

ORIGINAL PAGE IS OF POOR QUALITY

	PAYLOAD	TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	••••••	•••••••	•••••••	••••••	••••••	••••••	••••••	•••••••	••••••••••••••••••••••••••••••••
1	Amplifier	6	0.004	0.05	168	0.178	0.229	0.102	0.01	28	
2	Batteries	24	0.001	5.44	0	0.025	0.025	0.051	0.23	0	
3	Batteries, D-Cell	24	0.001	5.44	0	0.025	0.025	0.051	0.23	0	
4	Blood Press & Flow Instrument (animal)	1	0.030	10.00	50	0.300	0.500	0.200	10.00	50	
5	Carrier gas for Gas Chromatograph	1	0.800	20.00	0	0.928	0.928	0.929	20.00	0	Helium
6	Centrifuge, Hematocrit	1	0.001	1.00	0	0.200	0.100	0.050	1.00	0	
7	CO2 for Plants	1	0.057	50.00	0	0.203	0.203	1.372	50.00	0	
8	Doppler Expendables	1	0.002	0.91	0	0.152	0.102	0.102	0.91	0	
9	Fixation Kit	2	0.240	40.00	0	0.600	0.500	0.400	20.00	0	
10	Fluid Handling Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
11	Food (ea. Rat/90 day)	48	0.240	144.00	0	0.173	0.170	0.170	3.00	0	
12	Food (ea. Rhesus/90 day)	1	0.100	100.00	0	0.464	0.464	0.464	100.00	0	
13	Guillotine	1	0.012	2.00	0	0.200	0.400	0.150	2.00	0	
14	Hematology Analyzer	1	0.075	20.00	150	0.500	0.500	0.300	20.00	150	
15	Hematology Kit	1	0.024	10.00	0	0.400	0.200	0.300	10.00	0	
16	Histology Kit	1	0.036	10.00	0	0.300	0.400	0.300	10.00	0	
17	Histology Kit	1	0.036	10.00	0	0.300	0.400	0.300	10.00	0	
18	Lab Centrifuge Head	1	0.009	5.00	0	0.300	0.300	0.100	5.00	0	
19	Microscope Video Interface	1	0.005	22.00	0	0.200	0.150	0.150	22.00	0	
20	Microscope, Compound	1	0.072	13.00	30	0.600	0.200	0.600	13.00	30	
21	Microscope,dissecting	1	0.060	18.00	30	0.600	0.200	0.500	18.00	30	
22	Nutrient	1	0.001	20.00	0	0.100	0.100	0.100	20.00	0	
23	pH/Specific Ion Analyzer	1	0.010	3.00	5	0.200	0.200	0.200	3.00	5	
24	Photomicrographic Set-up	1	0.001	0.91	100	0.076	0.152	0.051	0.91	100	
25	Rodent Veterinary Kit	2	0.032	10.00	0	0.400	0.200	0.200	5.00	0	
26	Specimens (Plants)	50	0.000	0.00	0					0	Included in Plant Modular Habitat
27	Specimens (Rats)	48	0.000	24.00	0				0.50	0	Included in Modular Habitat
28	Specimens (Rhesus)	1	0.000	2.00	0				2.00	0	Included in Modular Habitat
29	Spectrometer,Proton/Heavy Ion	1	0.008	9.07	100	0.127	0.483	0.133	9.07	100	
30	Stowage (Expendables)	1	0.750	300.00	0	0.910	0.910	0.910	300.00	0	
31	Stowage (Expendables)	1	0.750	300.00	0	0.910	0.910	0.910	300.00	0	
32	Tapes, Data	26	0.015	1.82	0	0.076	0.152	0.051	0.07	0	
33	Water (ea. Rat/90 day)	48	0.240	240.00	0	0.173	0.170	0.170	5.00	0	
34	Water (ea. Rhesus/90 day)	1	0.005	100.00	0	0.170	0.170	0.170	100.00	0	
35	Water for cage washer (liters)	41	0.041	41.00	0	0.100	0.100	0.100	1.00	0	RESUPPLY AT 10% OF INITIAL LOAD
36	Wipes, Dry	1	0.001	0.10	0	0.150	0.100	0.050	0.10	0	
37	Wipes, Wet	1	0.002	0.10	0	0.150	0.100	0.100	0.10	0	
38	Failed Hardware Replacements (10%)		2.989	960.4							
39	Hardware For Changeout (2.5%)		0.747	240.1							
40											
41											
42	TOTALS FOR STOWED ITEMS		11.820	2744	633						
43											
44											

LAUNCH 3 RETURN - REFERENCE MISSION OPERATIONAL ANALYSIS DOCUMENT

	PAYLOAD TOTALS					ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••
1	Samples, Frozen		0.003	0.01							
2	Samples, Ambient or Refrigerated		0.414	41.00							
3	Waste, Solid		3.589	883.40							
4	Waste, Liquid		0.423	1024.13							
5	Specimens (Rats)	48	0.000	24.00					0.50		Transported in Modular Habitats
6	Failed Hardware (10%)		3.644	1228.38							
7	Hardware From Changeout (2.5%)		0.911	307.09							
8											
9	TOTAL RETURN LAUNCH 3		8.983	3508.02							
10											
11	Included in hardware return:										
12	Amplifier		0.000	0.00	0	0.178	0.229	0.102	0.00	28	
13	Data System	1	0.320	40.00	200	0.800	0.500	0.800	40.00	200	
14	Doppler Recorder	1	0.137	9.53	50	0.508	0.483	0.559	9.53	50	
15	Expmt Control and Data Interface	1	0.091	11.34	120	0.610	0.483	0.310	11.34	120	
16	Incubator	1	0.142	27.22	100	0.632	0.483	0.464	27.22	100	
17	Inflight Digitizing System	1	0.120	35.00	500	0.600	0.500	0.400	35.00	500	
18	Ion Selective Chromotograph	1	0.024	12.69	0	0.495	0.146	0.330	12.69		
19	Optokinetic Stimulus	1	0.033	17.45	0	0.261	0.483	0.261	17.45		
20	Physiol Hemodynamic Assessment Dev	1	0.001	0.53	0	0.100	0.100	0.100	0.53		
21	Reuter Microbiology Air Sampler	1	0.005	1.45	50	0.203	0.152	0.152	1.45	50	
22	Signal Conditioner, E O G	1	0.000	0.05	20	0.015	0.038	0.048	0.05	20	
23	Spectrometer,Proton/Heavy Ion	1	0.008	9.07	100	0.127	0.483	0.133	9.07	100	
24	Terminal, Computer	1	0.112	9.07	100	0.508	0.483	0.457	9.07	100	
25											
26											

		PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	••••••	••••••••••••••••••••••••••••••••••••
1	Batteries	24	0.001	5.44	0	0.025	0.025	0.051	0.23	0	
2	Batteries, D-Cell	24	0.001	5.44	0	0.025	0.025	0.051	0.23	0	
3	Doppler Expendables	1	0.002	0.91	0	0.152	0.102	0.102	0.91	0	
4	Fixation Kit	2	0.240	40.00	0	0.600	0.500	0.400	20.00	0	
5	Fluid Handling Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
6	Food (ea. Rat/90 day)	48	0.240	144.00	0	0.173	0.170	0.170	3.00	0	
7	Food (ea. Rhesus/90 day)	1	0.100	100.00	0	0.464	0.464	0.464	100.00	0	
8	Hematology Kit	1	0.024	10.00	0	0.400	0.200	0.300	10.00	0	
9	Histology Kit	1	0.036	10.00	0	0.300	0.400	0.300	10.00	0	
10	Histology Kit	1	0.036	10.00	0	0.300	0.400	0.300	10.00	0	
11	Nutrient	1	0.000	0.00	0					0	
12	Photomicrographic Set-up	1	0.001	0.91	100	0.076	0.152	0.051	0.91	100	
13	Stowage (Expendables)	1	0.750	300.00	0	0.910	0.910	0.910	300.00	0	
14	Stowage (Expendables)	1	0.750	300.00	0	0.910	0.910	0.910	300.00	0	
15	Tapes, Data	26	0.015	1.82	0	0.076	0.152	0.051	0.07	0	
16	Water (ea. Rat/90 day)	48	0.240	240.00	0	0.173	0.170	0.170	5.00	0	
17	Water (ea. Rhesus/90 day)	1	0.005	100.00	0	0.173	0.170	0.170	100.00	0	
18	Water for cage washer (liters)	41	0.041	41.00	0	0.100	0.100	0.100	1.00	0	RESUPPLY AT 10% OF INITIAL LOAD
19	Wipes, Dry	1	0.001	0.10	0	0.150	0.100	0.050	0.10	0	
20	Wipes, Wet	1	0.002	0.10	0	0.150	0.100	0.100	0.10	0	
21	Failed Hardware Replacements (10%)		3.239	1091.89							
22	Hardware For Changeout (2.5%)		0.810	272.97							
23											
24											
25	TOTALS FOR RESUPPLY ITEMS		6.548	2679.58	100						
26											
27											

ORIGINAL PAGE IS OF POOR QUALITY

LAUNCH 3-A RETURN - REFERENCE MISSION OPERATIONAL ANALYSIS DOCUMENT

	PAYLOAD TOTALS					ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••••
1	Samples, Frozen		0.003	0.01							
2	Samples, Ambient or Refrigerated		0.415	41.00							
3	Waste, Solid		3.589	883.40							
4	Waste, Liquid		0.423	1024.13							
5	Failed Hardware (10%)		3.644	1228.99							
6	Hardware From Changeout (2.5%)		0.911	307.25							
7											
8	TOTAL RETURN LAUNCH 3-A		8.985	3484.79							
9											
10											

APPENDIX F

LAUNCH PHASE 4

APPENDIX F TABLE OF CONTENTS

PHASE 4 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Metabolic Balance for Calcium (a)	X				X				X				X				X				X					
Bone Density (b)		X		X		X		X		X		X		X		X		X		X		X		X		X
Renal Stone Risk Factors (c)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hemodynamic Alterations (d)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dysrhythmia Assessment (e)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Neuromuscular Activity (f)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chromosomal Aberration Study & Dosimetry (i,j)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Exercise Program (l)*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circadian Rhythm of Plasma (n)			X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X					
Psychosocial Support (o)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Group Interaction (p)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Problem Solving (q)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Delayed Type Hypersensitivity (t)	X				X				X				X				X				X					
SMS Correlates (x) **	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Drug Pharmacokinetics & Drug Monitoring (y,z)	X			X			X			X				X			X			X			X			
EVA Work Output (ab,ac)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Microbial Study (ai, aj)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Histopathogenesis of Bone Loss (CH-A)						X						X														
Sex Differences/Bone Loss (CH-B)	X	X	X	X	X	X	X	X	X	X	X	X	X													
Determination of Regional Blood Flow (CS-A)														X	X	X	X	X	X	X	X	X	X	X	X	X
Hemodynamic Responses (CS-B)														X	X	X	X	X	X	X	X	X	X	X	X	X
Adrenergic Stimulation (CS-C)														X	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Weeks 1-2 for integration of equipment

* Exercise performed daily, not charged to life sciences.

** Ad-lib

PHASE 4 WEEKLY EXPERIMENT SCHEDULE

EXPERIMENT	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chronotropic Stimulation (CS-D)														X	X	X	X	X	X	X	X	X	X	X	X	X
Peripheral Vascular Assessment (CS-E)	X	X	X	X	X	X	X	X	X	X	X	X	X													
Immune Response (IM-C)														X	X	X	X	X	X	X	X	X	X	X	X	X
Muscle Loss I (MS/F-A)															X		X				X				X	
Muscle Loss III (MS/F-C)	X	X	X	X				X				X														
Gravity-sensitive Neurons (NS-I)														X	X	X	X	X	X	X	X	X	X	X	X	X

NOTES: Weeks 1-2 for integration of equipment

C-3

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 4 - BmRP

Experiment	Hours
a	51.0
b	48.1
c	13.0
d	163.0
e	83.2
f	82.3
i,j	13.0
l*	1422.0
n	80.0
o	39.0
p	26.0
q	78.0
t	18.0
x	13.0
y,z	19.2
ab,ac	91.0
ai,aj	20.8
SUB-TOTAL BmRP	838.6

* Exercise, time not charged to Life Sciences

PHASED SEQUENCE CREW HOUR REQUIREMENTS

(180 Day Scenario)

Phase 4 - BRP

Experiment	Hours
CH-A	10.0
CH-B	125.0
IM-C	8.5
MS/F-A	82.1
MS/F-C	60.0
NS-I	0.0
CS-A	8.4
CS-B	16.8
CS-C	16.8
CS-D	16.8
CS-E	16.8
Specimen Servicing	598.0
SUBTOTAL BRP	959.2
SUBTOTAL BmRP	838.6
HARDWARE SERVICE/MAIN.	156.0
TOTAL PHASE 4	1953.8

SKILL MIX ASSESSMENT - LAUNCH 4

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
CALCIUM HOMEOSTASIS (a,b,c)	URINE COLLECTION SAMPLE PREP FECES COLLECTION	NONE (SKILLED)	HEALTHY NORMOTENSIVE	NO	
CARDIOVASCULAR SYSTEM (d,e)	ECHO BLOOD COLLECTION SAMPLE PREP LBNP URINE COLLECTION	NONE (SKILLED)	HEALTHY, ETC. NORMOTENSIVE NON-SMOKERS ANATOMY GIVES QUANTITATIVE ECHO DATA	NO	
MUSCLE PHYSIOLOGY (f)	DON ACCELEROMETER DON FORCE MEAS. DEVICE	NONE (SKILLED)	HEALTHY (NO PREVIOUS HISTORY OF MUSCLE DISEASE)	NO	
RADIATION EFFECTS/ RADIOBIOLOGY (i,j)	DOSIMETER/SPECTR. MAINTENANCE	NONE (SKILLED)	HEALTHY	NO	
EXERCISE PHYSIOLOGY (l)	PERFORM ISOKINETIC EXERCISE PERFORM AEROBIC EXERCISE PERFORM ANAEROBIC EXERCISE	NONE (SKILLED)	HEALTHY	NO	

1

SKILL MIX ASSESSMENT - LAUNCH 4

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS HUMAN	ANIMAL
ENDOCRINOLOGY/ FLUID ELECTROLYTES (n)	URINE COLLECTION SAMPLE PREP VENOUS PRES.	NONE (SKILLED)	HEALTHY	NO	
BEHAVIORAL RESEARCH (o,p,q)	DATA PUNCH (COMPUTER QUEST.)	NONE (SKILLED)	NONE	NO	
IMMUNOLOGY (t)	ISOTOPE INJECTION SAMPLE PREP	NONE (SKILLED)	HEALTHY	NO	
NEUROSCIENCE (x)	OCULAR NYSTAGMUS (OPERATION OF QUALITY CONTROL & DISPLAY SYSTEM)	NONE (SKILLED)	HEALTHY (NORMAL VESTIBULAR RESPONSES SUBJ. WITH EXTREME SUSCEPTIBILITY TO SPACE MOTION SICK-NESS NOT ACCEPTABLE)	NO	
PHARMACOKINETICS (y,z)	URINE COLLECTION SAMPLE PREP ST'D LAB EQUIPMENT OPERATION DRUG ADM	NONE (SKILLED)	HEALTHY	NO	

2

SKILL MIX ASSESSMENT - LAUNCH 4

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
PULMONARY PHYSIOLOGY (ab,ac,)	REBR. DEVICE BMMD SAMPLE PREP ALFE OPERATION	NONE (SKILLED)	HEALTHY (NON-SMOKERS)	NO	
MICROBIOLOGY (ai,aj)	SAMPLE COLLECTION PHOTOMICROGRAPH OPERATION INCUBATOR OPERATION	NONE (SKILLED)	NONE	NO	
CALCIUM HOMEOSTASIS (CH-A, CH-B)	ANIMAL SURGERY TISSUE COLLECTION URINE COLLECTION PHOTON ABSORPTION FECAL COLLECTION BLOOD COLLECTION	NONE (SKILLED)	ADULT 4 RHESUS MONKEYS		YES 4 MALE (CH-A) 4 MALE 4 FEMALE (CH-B)

SKILL MIX ASSESSMENT - LAUNCH 4

DISCIPLINE TITLE	TASK	SCIENCE BACKGROUND	SUBJECT REQUIREMENTS	GENDER REQUIREMENTS	
				HUMAN	ANIMAL
CARDIOVASCULAR SYSTEM (CS-A, CS-B, CS-C, CS-D, CS-E)	BLOOD COLLECTION ISOTOPE INJECTION SAMPLE PREP URINE COLLECTION	NONE (SKILLED)	HEALTHY 4 RHESUS MONKEYS		YES ADULT MALES
IMMUNOLOGY (IM-C)	ANIMAL CARE	NONE (SKILLED)	HEALTHY 12 RATS		NO
MUSCLE STRUCTURE & FUNCTION (MS/F-A, MS/F-C)	SMALL ANIMAL SURG. CLAMP-FREEZE TISSUE TISSUE FIXATION BIOCHEMICAL ANALY. OF TISSUE MEASURE CONTRACTIL PROPERTIES MONITOR EMG ACTIV.	NONE (SKILLED)	24 RATS (A) 24 RATS (C)		YES ADULT MALE RATS
NEUROSCIENCE (NS-I)	ANIMAL CARE	NONE (SKILLED)	HEALTHY 2 SQUIRREL MONKEYS		NO

PHASED SEQUENCE TRAINING REQUIREMENTS: L-4

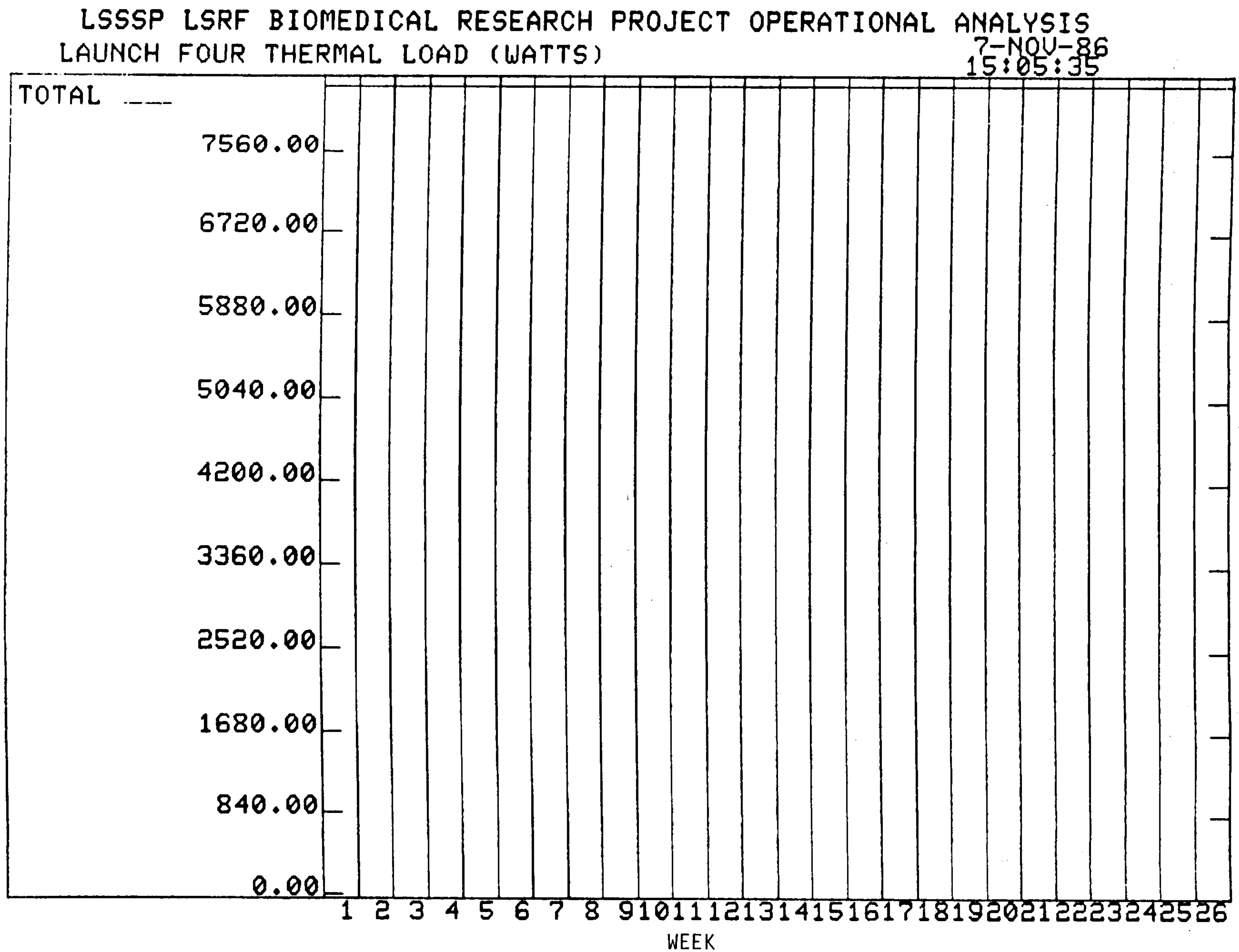
DISCIPLINE	NAME	OPERATOR	SUBJECT
RABIOBIOLOGY			
	CHROMOSOMAL ABERRATION STUDY AND DOSIMETRY FOR ALL LIFE SCIENCES SUBJECTS (i, j)	8	4
MUSCLE STRUCTURE & FUNCTION			
	MUSCLE LOSS IN RATS IN MICROGRAVITY:		
	I. HISTOLOGY/HISTOCHEMISTRY (MS/F-A)	28	0
	II. ELECTRON MICROSCOPE/CONTRACTILE PROPERTIES (MS/F-C)	44	0
ENDOCRINOLOGY/FLUID ELECTROLYTES			
	CIRCADIAN RHYTHM OF PLASMA HORMONES AND SERUM ELECTROLYTES DURING WEIGHTLESSNESS (n)	16	4
BEHAVIORAL RESEARCH			
	THE EFFECTIVENESS OF INDIVIDUALLY TAILORED PSYCHOSOCIAL SUPPORT METHODS IN ACTUAL SPACEFLIGHT SETTINGS (o)	8	-
	GROUP INTERACTION, COMPATIBILITY, AND EFFECTIVENESS (p)	8	-
	PROBLEM SOLVING (q)	16	-
IMMUNOLOGY			
	DELAYED TYPE HYPERSENSITIVITY (t)	12	4
	EFFECT OF SPACEFLIGHT ON IMMUNE RESPONSE; MITOGEN RESPONSE TO LEUKOCYTES POSTFLIGHT (IM-C)	0	0
NEUROSCIENCE			
	SMS CORRELATES (x)	8	-
	RECOVERY OF FUNCTION OF GRAVITY-SENSITIVE VESTIBULAR NERVE NEURONS IN EARTH'S GRAVITY AFTER EXPOSURE TO MICROGRAVITY (NS-I)	4	-

PHASED SEQUENCE TRAINING REQUIREMENTS: L-4

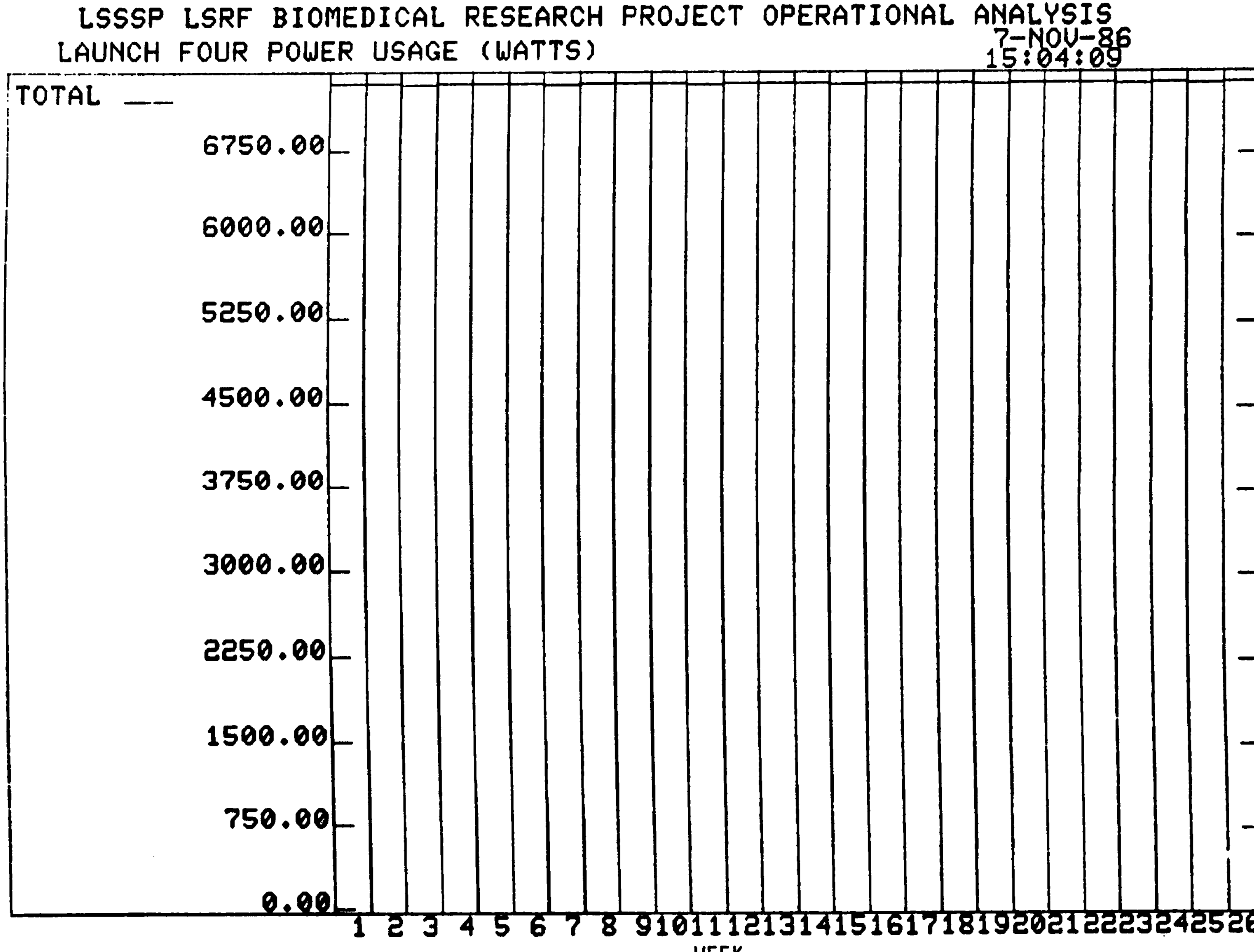
DISCIPLINE	NAME	OPERATOR	SUBJECT
CALCIUM HOMEOSTASIS			
	METABOLIC BALANCE FOR CALCIUM AND OTHER BONE RELATED CONSTITUENTS (a)	16	16
	BONE DENSITY MEASUREMENTS (b)	20	8
	MEASUREMENTS OF RENAL STONE RISK FACTORS (c)	8	8
	HISTOPATHOGENESIS OF BONE LOSS IN MICROGRAVITY (CH-A)	20	-
	SEX DIFFERENCES IN LOSS OF BONE FROM DIFFERENT SKELETAL SITES (CH-B)	24	-
CARDIOVASCULAR			
	FULL ASSESSMENT OF HEMODYNAMIC ALTERATIONS (d)	40	16
	DYSRHYTHMIA ASSESSMENT (e)	24	8
	EFFECT OF SPACEFLIGHT ON CARDIOVASCULAR CONTROL IN RHESUS MONKEYS:		
	I. NEUROENDOCRINE RESPONSE WITH DETERMINATION OF REGIONAL BLOOD FLOW (CS-A)	`30	0
	II. HEMODYNAMIC RESPONSES TO VOLUME CHANGES (CS-B)	18	0
	III. CENTRAL AND REGIONAL HEMODYNAMIC RESPONSES TO ADRENERGIC STIMULATION AND BLOCKADE (CS-C)	24	0
	IV. CARDIAC AND CORONARY RESPONSE WITH AND WITHOUT CHRONOTROPIC STIMULATION (CS-D)	28	0
	V. COMPREHENSIVE CARDIAC AND PERIPHERAL VASCULAR ASSESSMENT (CS-E)	24	0
MUSCLE PHYSIOLOGY			
	MEASUREMENT OF INFLIGHT NEUROMUSCULAR ACTIVITY (f)	30	15
	EXERCISE PROGRAM FOR SPACEFLIGHT (l)	8	8

PHASED SEQUENCE TRAINING REQUIREMENTS: L-4

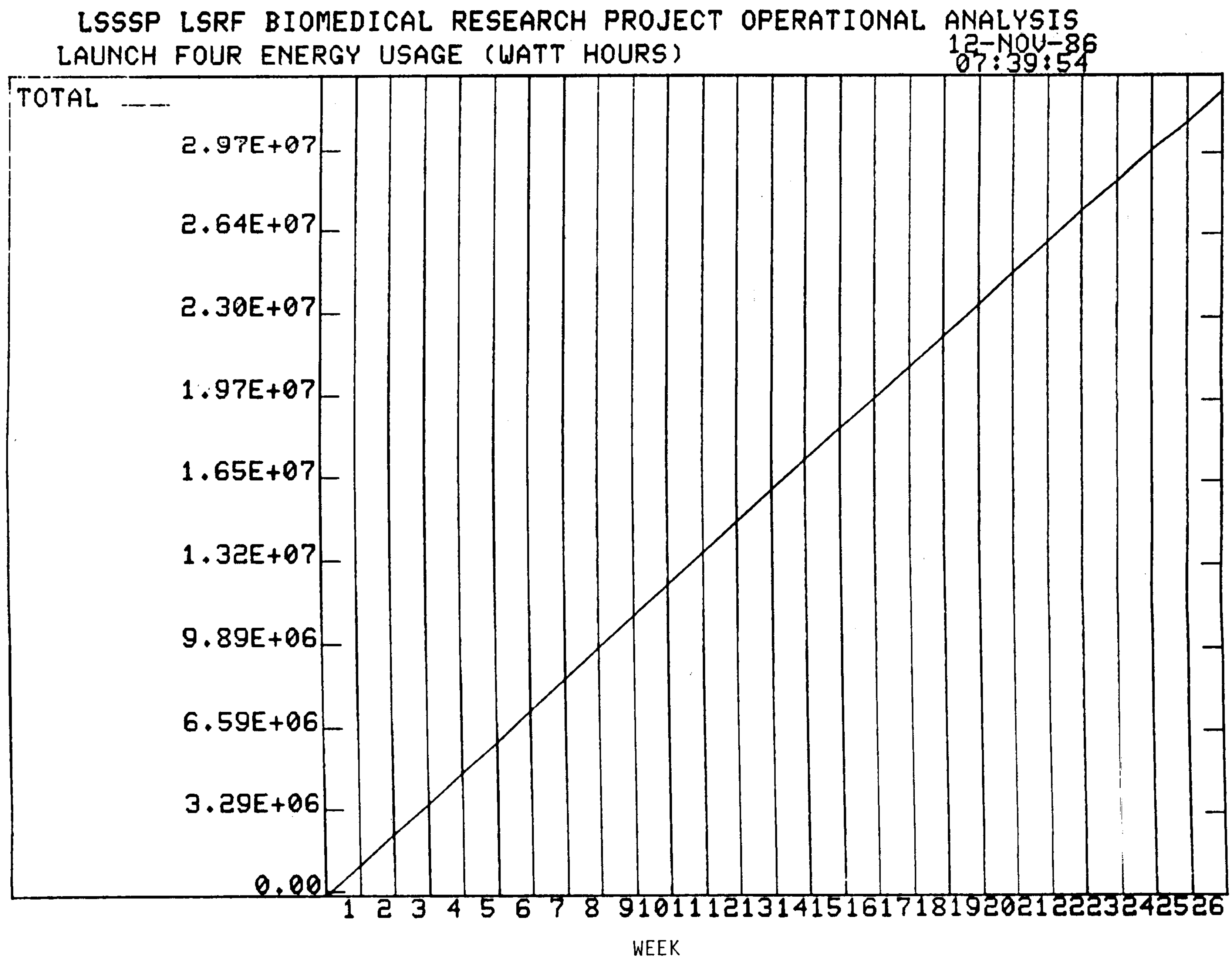
DISCIPLINE	NAME	OPERATOR	SUBJECT
PHARMACOKINETICS			
	DRUG PHARMACOKINETICS IN SPACE AND EVALUATION OF MODERN NON-INVASIVE METHODS FOR CLINICAL DRUG MONITORING (y, z)	16	8
PULMONARY PHYSIOLOGY			
	EVALUATE EVA WORK OUTPUT AND CARDIOVASCULAR RESPONSE (ab, ac)	24	16
MICROBIOLOGY			
	CREWMEMBER AND SPACE STATION MICROBIAL STUDY (ai, aj)	16	8
	TOTAL TASK	522	123
	TOTAL GENERIC	336	0
	TOTAL PHASE/INTEGRATED	80	0
	TOTAL L-4 TRAINING	938	123



Thermal Load Profile for Launch 4

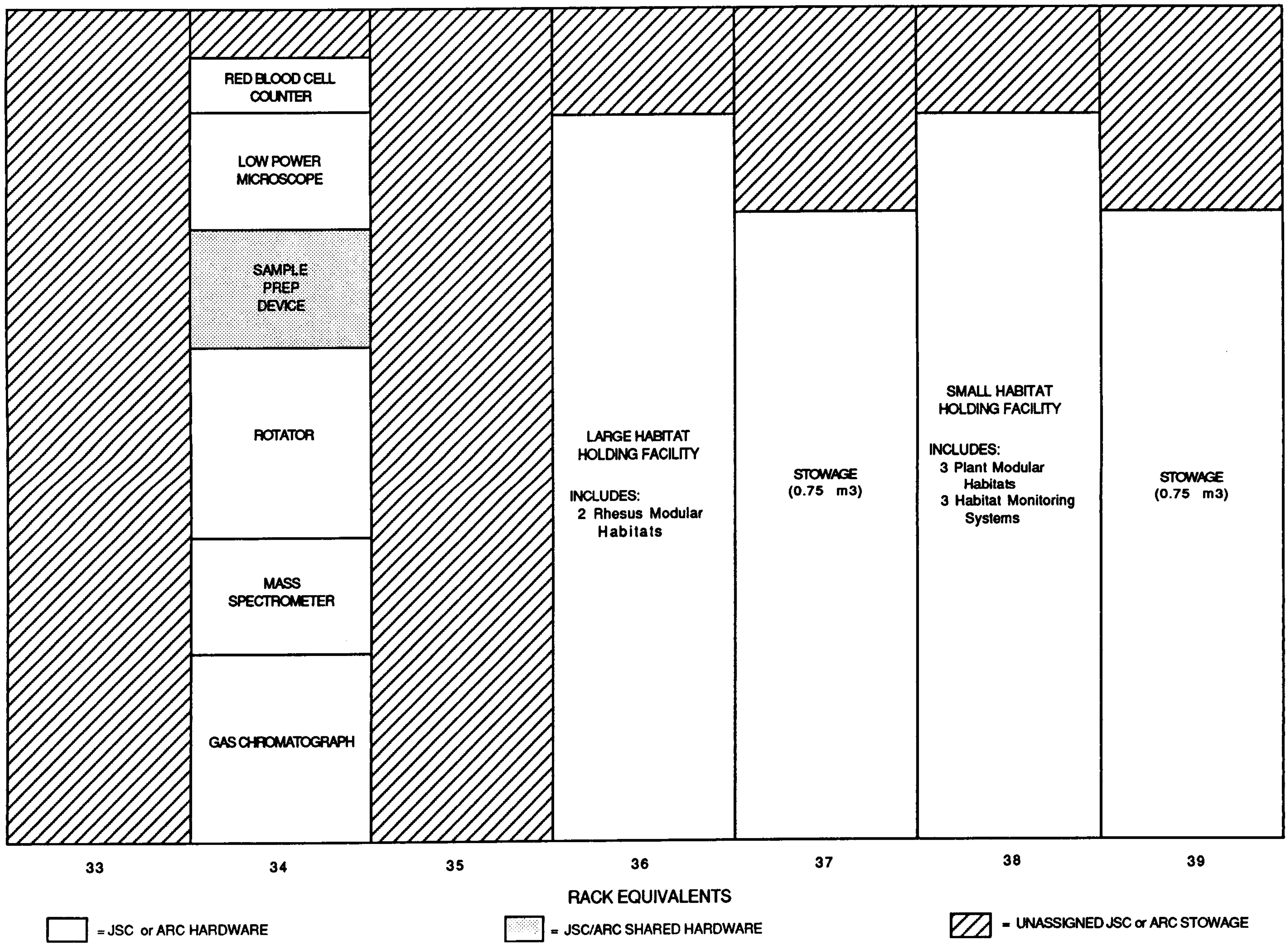


Power Profile for Launch 4



ENERGY PROFILE FOR LAUNCH FOUR

PHASE 4



RED BLOOD CELL COUNTER
LOW POWER MICROSCOPE
SAMPLE PREP DEVICE
ROTATOR
MASS SPECTROMETER
GAS CHROMATOGRAPH
LARGE HABITAT HOLDING FACILITY
INCLUDES:
2 Rhesus Modular Habitats
STOWAGE (0.75 m3)
SMALL HABITAT HOLDING FACILITY
INCLUDES:
3 Plant Modular Habitats
3 Habitat Monitoring Systems
STOWAGE (0.75 m3)
33
34
35
36
37
38
39
RACK EQUIVALENTS
= JSC or ARC HARDWARE
= JSC/ARC SHARED HARDWARE
= UNASSIGNED JSC or ARC STOWAGE

LAUNCH 4 RACK MOUNTED HARDWARE - REFERENCE MISSION OPERATIONAL ANALYSIS DOCUMENT

		PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
1	Counter, Red Blood Cell	1	0.034	45.36	50	0.537	0.483	0.133	45.36	50	
2	Gas Chromatograph	1	0.200	25.00	100	0.800	0.500	0.500	25.00	100	
3	Habitat monitoring system	4	0.000	80.00	100	0.660	0.406	0.356	20.00	25	Included in Holding Facility
4	HRF Terminal	1	0.112	22.68	15	0.508	0.483	0.457	22.68	15	
5	Large Habitat Holding Facility	2	0.750	300.00	500	0.910	0.530	2.130	150.00	250	
6	Mass Spectrometer	1	0.075	40.00	150	0.500	0.500	0.300	40.00	150	
7	Microscope, Low Power	1	0.013	7.26	100	0.229	0.190	0.305	7.26	100	
8	Plant Modular Habitat	3	0.000	120.00	750	0.660	0.406	0.356	40.00	250	Included in Holding Facility
9	Rhesus Modular Habitat	2	0.382	300.00	500	0.660	0.406	0.712	150.00	250	Included in Holding Facility
10	Rotator	1	0.125	40.82	220	0.508	0.483	0.508	40.82	220	
11	Sample Prep. Dev., Fluid X-fer	1	0.179	11.33	150	0.609	0.483	0.609	11.33	150	
12	Small Habitat Holding Facility	1	1.027	150.00	250	0.910	0.530	2.130	150.00	250	
13											
14											
15	TOTALS FOR RACK MOUNTED EQUIPMENT		2.898	1142.45	2885						
16											
17											

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		PAYLOAD TOTALS				ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••
1	Agar Plates	1116	0.103	50.62	0	0.076	0.076	0.016	0.05	0	
2	Agar Strips	754	0.001	398.87	0	0.100	0.100	0.100	0.53	0	
3	Blood Collection Disposables	2160	0.027	122.45	0	0.013	0.013	0.076	0.06	0	
4	Blood Collection Reusables	1	0.028	1.36	0	0.305	0.305	0.305	1.36	0	
5	Camera, 35 mm	1	0.010	1.50	0	0.200	0.200	0.250	1.50	0	
6	Camera, Polaroid	1	0.002	1.00	0	0.100	0.150	0.150	1.00	0	
7	Cation Exchange Resin Kit	3	0.002	0.41	0	0.102	0.076	0.076	0.14	0	
8	Cell Culture Expendables	24	0.079	41.76	0	0.127	0.254	0.102	1.74	0	
9	Cell Handling Accessories	24	0.011	16.33	0	0.152	0.102	0.029	0.68	0	
10	Computer, Stimulus Control	1	0.033	14.97	80	0.424	0.434	0.178	14.97	80	
11	Cr51 Tagging Kit/Shield	2	0.100	0.11	0	1.408	0.279	0.254	0.05	0	
12	Display, Venous Press Recorder	1	0.004	2.27	25	0.305	0.051	0.229	2.27	25	
13	Elisa Analysis Chemicals	3	0.001	0.00	0	0.076	0.254	0.052	0.00	0	
14	Elisa Reader	1	0.030	15.87	0	0.229	0.200	0.050	15.87	0	
15	Evans Blue Dye Injection Kit	144	0.028	11.61	0	0.051	0.051	0.076	0.08	0	
16	Expmt Control and Data Interface	1	0.091	11.34	120	0.610	0.483	0.310	11.34	120	
17	Film	5	0.125	10.00	0	0.500	0.500	0.100	2.00	0	
18	Filter Kit, Millipore	1	0.028	0.23	0	0.305	0.305	0.305	0.23	0	
19	Filters, Millipore	36	0.001	0.16	0	0.076	0.076	0.006	0.00	0	
20	Fixation Kit	1	0.120	20.00	0	0.600	0.500	0.400	20.00	0	
21	Food (ea. Rat/90 day)	48	0.240	144.00	0	0.173	0.170	0.170	3.00	0	
22	Food (ea. Rhesus/90 day)	2	0.200	200.00	0	0.464	0.464	0.464	100.00	0	
23	Helmet Assembly	1	0.046	5.23	20	0.470	0.310	0.318	5.23	20	
24	Helmet Interface Box	1	0.023	7.96	30	0.457	0.330	0.152	7.96	30	
25	Helmet Restraint	1	0.000	0.23	0	0.076	0.076	0.025	0.23	0	
26	Heparin Lock Kit	140	0.013	9.44	0	0.203	0.076	0.006	0.07	0	
27	Iodine Isotope Kit/Shield	6	0.100	1.00	0	0.455	0.483	0.455	0.17	0	
28	Isotope Kit, Fe59/Shield	4	0.100	1.00	0	0.455	0.483	0.455	0.25	0	
29	Loops, Sterile	754	0.074	12.22	0	0.203	0.076	0.006	0.02	0	
30	Mitogen Kit	24	0.001	12.48	0	0.051	0.102	0.192	0.52	0	
31	Nutrient	1	0.001	20.00	0	0.100	0.100	0.100	20.00	0	
32	Phycol & P B S Consumables Kit	102	0.161	106.42	0	0.152	0.102	0.102	1.04	0	
33	Plant Care Kit	1	0.010	10.00	0	0.215	0.215	0.215	10.00	0	
34	Plant Care Kit	1	0.010	10.00	0	0.215	0.215	0.215	10.00	0	
35	Plant Harvesting Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
36	Plant Harvesting Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
37	Radioisotopes/ Shielding	1	0.100	1.00	0	0.455	0.483	0.455	1.00	0	
38	Reagent Kit, Red Cell Mass	4	0.001	0.36	0	0.076	0.051	0.051	0.09	0	
39	Reticulocyte Smear Kit	4	0.001	0.36	0	0.076	0.076	0.013	0.09	0	
40	Reuter Microbiology Air Sampler	1	0.005	1.45	50	0.203	0.152	0.152	1.45	50	
41	Rodent Veterinary Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
42	Sample Swabs and Sample Tubes	1080	0.053	24.50	0	0.025	0.025	0.076	0.02	0	
43	Seed Planting Kit	1	0.016	5.00	150	0.400	0.200	0.200	5.00	150	
44	Seed Planting Kit	1	0.016	5.00	150	0.400	0.200	0.200	5.00	150	

LAUNCH 4 STOWED - REFERENCE MISSION OPERATIONAL ANALYSIS DOCUMENT

	PAYLOAD	TOTALS			ITEM CHARACTERISTICS					
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	••••••	••••••••••••••••••••••••••••••••••
45	Slide Prep Device, Chromosal	1	0.003	3.27	0	0.368	0.211	0.044	3.27	0	
46	Specimens (Plants)	50	0.001	500.00	0	0.010	0.010	0.010	10.00	0	Included in Holding Facility
47	Specimens (Rats)	48	0.000	24.00	0				0.50	0	Included in Holding Facility
48	Specimens (Rhesus)	2	0.000	4.00	0				2.00	0	Included in Holding Facility
49	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
50	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
51	Transducer, Venous Pressure	1	0.000	0.68	0	0.102	0.051	0.051	0.68	0	
52	Trypticase Soy Agar Strips	120	0.000	0.54	0	0.025	0.076	0.000	0.00	0	
53	Tubes, Blood Collection	1080	0.013	61.13	0	0.013	0.013	0.076	0.06	0	
54	Tubes, Blood Collection, Spares	108	0.001	6.11	0	0.013	0.013	0.076	0.06	0	
55	Venous Pressure Disposables	156	0.002	8.83	0	0.013	0.013	0.076	0.06	0	
56	Water (ea. Rat/90 day)	48	0.240	240.00	0	0.173	0.170	0.170	5.00	0	
57	Water (ea. Rhesus/90 day)	2	0.010	200.00	0	0.173	0.170	0.170	100.00	0	
58	Water for Plants (liters)	400	0.400	400.00	0	0.100	0.100	0.100	1.00	0	
59	Wipes, Dry	1	0.001	0.10	0	0.150	0.100	0.050	0.10	0	
60	Wipes, Wet	1	0.002	0.10	0	0.150	0.100	0.100	0.10	0	
61	Failed Hardware Replacements (10%)		3.797	1424.3							
62	Hardware For Changeout (2.5%)		0.949	356.1							
63											
64											
65	TOTALS FOR STOWED ITEMS		9.815	3362.26	625						
66											
67											

	PAYLOAD	TOTALS		ITEM CHARACTERISTICS						
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••••
1	Samples, Frozen		0.003	0.01							
2	Samples, Ambient or Refrigerated		0.414	41.00							
3	Waste, Solid		3.589	883.40							
4	Waste, Liquid		0.423	1024.13							
5	Habitat monitoring system (Rhesus)	1	0.000	20.00	25	0.406	0.355	0.152	20.00	25	Included in Holding Facility
6	Rhesus Modular Habitat	1	0.000	150.00	250				150.00	250	Included in Holding Facility
7	Specimens (Rats)	48	0.000	24.00	0				0.50		Transported in modular habitats
8	Specimens (Rhesus)	1	0.000	2.00	0				2.00		Transported in modular habitats
9	Failed Hardware (10%)		3.797	1424.26							
10	Hardware From Changeout (2.5%)		0.949	356.07							
11											
12	TOTAL LAUNCH 4 RETURN		9.174	3924.87							
13											
14											

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	PAYLOAD	TOTALS			ITEM CHARACTERISTICS					
	EQUIPMENT NAME	QTY Reqd	VOL cu m	MASS kg	POWER watts	DEPTH m	WIDTH m	HEIGHT m	MASS kg	POWER watts	REMARKS
•••	••••••••••••••••••••••••••••	•••••	•••••••	•••••••	•••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••
1	Agar Plates	1116	0.103	50.62	0	0.076	0.076	0.016	0.05	0	
2	Agar Strips	754	0.001	398.87	0	0.100	0.100	0.100	0.53	0	
3	Blood Collection Disposables	2160	0.027	122.45	0	0.013	0.013	0.076	0.06	0	
4	Blood Collection Reusables	1	0.028	1.36	0	0.305	0.305	0.305	1.36	0	
5	Cation Exchange Resin Kit	3	0.002	0.41	0	0.102	0.076	0.076	0.14	0	
6	Cell Handling Accessories	102	0.046	69.40	0	0.152	0.102	0.029	0.68	0	
7	Elisa Analysis Chemicals	3	0.001	0.00	0	0.076	0.254	0.052	0.00	0	
8	Evans Blue Dye Injection Kit	144	0.028	11.61	0	0.051	0.051	0.076	0.08	0	
9	Expmt Control and Data Interface	1	0.091	11.34	120	0.610	0.483	0.310	11.34	120	
10	Film	5	0.125	10.00	0	0.500	0.500	0.100	2.00	0	
11	Filter Kit, Millipore	1	0.028	0.23	0	0.305	0.305	0.305	0.23	0	
12	Filters, Millipore	36	0.001	0.16	0	0.076	0.076	0.006	0.00	0	
13	Fixation Kit	1	0.120	20.00	0	0.600	0.500	0.400	20.00	0	
14	Food (ea. Rat/90 day)	48	0.240	144.00	0	0.173	0.170	0.170	3.00	0	
15	Food (ea. Rhesus/90 day)	2	0.200	200.00	0	0.464	0.464	0.464	100.00	0	
16	Heparin Lock Kit	140	0.013	9.44	0	0.203	0.076	0.006	0.07	0	
17	Isotope Kit, Fe59/Shield	4	0.100	0.36	0	0.455	0.483	0.455	0.09	0	
18	Loops, Sterile	754	0.074	12.22	0	0.203	0.076	0.006	0.02	0	
19	Mitogen Kit	24	0.001	12.48	0	0.051	0.102	0.192	0.52	0	
20	Nutrient	1	0.001	20.00	0	0.100	0.100	0.100	20.00	0	
21	Phycol & P B S Consumables Kit	102	0.161	106.42	0	0.152	0.102	0.102	1.04	0	
22	Plant Harvesting Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
23	Plant Harvesting Kit	1	0.016	5.00	0	0.400	0.200	0.200	5.00	0	
24	Radioisotopes/ Shielding	1	0.100	1.00	0	0.455	0.483	0.455	1.00	0	
25	Reagent Kit, Red Cell Mass	4	0.001	0.36	0	0.076	0.051	0.051	0.09	0	
26	Reticulocyte Smear Kit	4	0.001	0.36	0	0.076	0.076	0.013	0.09	0	
27	Sample Swabs and Sample Tubes	1080	0.053	24.50	0	0.025	0.025	0.076	0.02	0	
28	Slide Prep Device, Chromosal	1	0.003	3.27	0	0.368	0.211	0.044	3.27	0	
29	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
30	Stowage (Expendables)	1	0.754	300.00	0	0.910	0.910	0.910	300.00	0	
31	Trypticase Soy Agar Strips	120	0.000	0.54	0	0.025	0.076	0.000	0.00	0	
32	Tubes, Blood Collection	1080	0.013	61.13	0	0.013	0.013	0.076	0.06	0	
33	Venous Pressure Disposables	156	0.002	8.83	0	0.013	0.013	0.076	0.06	0	
34	Water (ea. Rat/90 day)	48	0.240	240.00	0	0.173	0.170	0.170	5.00	0	
35	Water (ea. Rhesus/90 day)	2	0.010	200.00	0	0.173	0.170	0.170	100.00	0	
36	Water for Plants (liters)	400	0.400	400.00	0	0.100	0.100	0.100	1.00	0	
37	Wipes, Dry	1	0.001	0.10	0	0.150	0.100	0.050	0.10	0	
38	Wipes, Wet	1	0.002	0.10	0	0.150	0.100	0.100	0.10	0	
39	Failed Hardware Replacements (10%)		4.172	1699.4							
40	Hardware For Changeout (2.5%)		1.043	424.9							
41											
42											
43	TOTALS FOR RESUPPLY ITEMS		3.757	2751.56	120						
44											

	PAYLOAD	TOTALS			ITEM CHARACTERISTICS						
		QTY	VOL	MASS	POWER	DEPTH	WIDTH	HEIGHT	MASS	POWER	
	EQUIPMENT NAME	Reqd	cu m	kg	watts	m	m	m	kg	watts	REMARKS
•••	••••••••••••••••••••••••••••••	•••••	•••••••	••••••••	••••••••	••••••	••••••	••••••	•••••••	•••••••	••••••••••••••••••••••••••••••••••••••
1	Samples, Frozên		0.123	20.00							
2	Samples, Ambient or Refrigerated		0.439	45.00							
3	Waste, Solid		3.589	883.40							
4	Waste, Liquid		0.423	1024.13							
5	Habitat monitoring system (Rhesus)	1	0.000	20.00	25	0.406	0.355	0.152	20.00	25	Included in Holding Facility
6	Rhesus Modular Habitat	1	0.000	150.00	250				150.00	250	Included in Holding Facility
7	Specimens (Rats)	48	0.000	24.00	0				0.50		
8	Specimens (Rhesus)	1	0.000	2.00	0				2.00		
9	Failed Hardware (10%)		3.797	1424.26							
10	Hardware From Changeout (2.5%)		0.949	356.07							
11											
12	TOTAL LAUNCH 4-A RETURN		9.320	3948.86							
13											
14											

1. Report No. NASA TM-89604	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Reference Mission Operational Analysis Document (RMOAD) for the Life Sciences Research Facilities		5. Report Date January 1987
		6. Performing Organization Code EBF
7. Author(s)		8. Performing Organization Report No.
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16. Abstract

The Space Station will be constructed during the next decade as an orbiting, low-gravity, permanently facility. The facility will provide a multitude of research opportunities for many different users. The pressurized research laboratory will allow life scientists to study the effects of long-term exposure to microgravity on humans, animals, and plants. The results of these studies will increase our understanding of this foreign environment on basic life processes and ensure the safety of man's long-term presence in space.

This document establishes initial operational requirements for the use of the Life Sciences Research Facility (LSRF) during its construction.

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